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A Treatise on Drinking Water

By JAMES H. DEVINE

TRUSTEE OF SACRAMENTO

A
TREATISE
ON
DRINKING WATER

BY

JAMES H. DEVINE

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News Publishing Company
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A Plain Frank Review of an Important Question.

183023

To the Property Owners, Tax Payers, My Fellow Townsmen, and the Whole People of this wronged, maligned, and much misrepresented community:

I desire most cordially, but earnestly, and without prejudice to any man or set of men, of any profession or calling, but in self-defense to myself and for the protection of those whose interests are identical with mine, who have worked industriously for years to accumulate a little property that they may spend their declining years in ease and comfort as the reward of their enterprise, energy and foresight; and also the home owners and the toiling masses who produce all the wealth, pay all the taxes, and off whom all the drones of society live, and to all residents of our most favored city and those who contemplate residing with us, of whom, no doubt, their would be thousands were the great commercial advantages, manufacturing facilities, and the salubrity of our climate properly explained and presented to people desiring such inestimable advantages, to dedicate this article on the most vitally important question of all others affecting the interests of the human race, and particularly that portion of it residing in this city who have been most grossly misled and falsely instructed on this most interesting subject for a number of years past. This is the subject of drinking water, which greatest of all public and private necessities on earth has attracted and received the attention of doctors, chemists, bacteriologists, philosophers, and philanthropists, and even historians since the commencement of all human life on this earth. And particularly has this most important of all questions affecting the interests of mankind attracted the attention of the wisest and most progressive of the race since people commenced to congregate in communities of villages, towns, and cities for mutual benefit, protection, and the easy exchange of commodities, and the promotion and development of commercial relations with each other and the different peoples of the world.

And I have at my command ten thousand irrefutable proofs that it was at the beginning, and still remains, the judgment of mankind to build and maintain their large and small communities on the banks of rivers for numerous good reasons, first, and most prominent among which it was the intention of God Almighty, who created them for the use, benefit, and pleasure of man, of which fact we have ample proof. For in the Garden of Eden, at the very seat of creation, he placed a river to supply the necessities of Adam and Eve and their numerous progeny. "And a river went out of the place of pleasure to water paradise, which from thence is divided into four heads." Genesis ii, 10.

And the next reason of most vital importance was, and still remains with us, to obtain a sufficient and never-failing supply of pure, wholesome water, ample and convincing proof of which can be seen on every side we look for it, as well as in our travels and experiences through life. And if you would only stop for a brief moment to ponder over this subject we would, no doubt, profit by the experience of mankind from the commencement of the world to this day inclusive.

For instance, we find the following ancient cities were built on the banks of rivers of antiquity: The cities of Adam, Jericho, and many other towns and villages on the Jordan, received their drinking water for all domestic purposes from said river. Babylon and many other towns and populous cities were built on the banks of the Euphrates, and all those cities were supplied with drinking water from that river. Nineveh, Calah, Resen, and several other cities adorned the banks of the Tigris, and the people of those cities supplied themselves with water from that river. Memphis, and grand Cairo, Thebes, and numerous other cities were built on the banks of the Nile, the magnificent waters of which have received the attention of some of the most eminent historians, philosophers, and water experts ever since the actions and thoughts of mankind have been crystallized into written words and sentences. And they have all with one voice extolled its superior qualities, declaring it to be the most pleasant and nutritive in the world. Why it should be so Plato could not conceive, nevertheless he states such to be the case, and he relates, "the Egyptian priests refrained from giving it to drink to their bull god Apis on account of its fattening properties."

This river has been explored for at least twenty-seven hundred miles, and has two immense tributaries, the Baher and the E Azrak, all of which rise in the mountains of Abyssinia, and wash down those mountains the Soudan and all that low country, including Egypt, from their source to Abouker Bay. And still the water of the Nile is pronounced by all water experts to be the purest and most wholesome of all other drinking water.

We are frequently informed by our local pseudo water experts that the reason Sacramento River water is polluted this dry season is on account of its being so very low, when common sense should dictate to any man that a river is freer from pollution when it is very low than at any other season, for the reason that all small creeks and possible contaminating tributaries are dried up; and therefore, we have nothing in the river in dry seasons but pure spring water, with the antimony and all other mineral poisons precipitated, and ammonia, sulphuric, and other poisonous acids evaporated from this water by the sun, air, and sand in the bed and sides of the river—all of which are the best filters in the world—and the constant motion of the river, which is the most important factor and means of preparation and purification, which is perfectly accomplished by the very laws of nature and upon the simple but perfect plan of the Creator, whose works man has never been thus far able to improve. Again, we are told by our necromancing doctors and their scheme-executing newspaper allies that the river water cannot be wholesome when the river is swollen from an abundance of rain, and the numerous freshets caused thereby, because it has to drain such an immense tule basin and the great overflow north of this city.

I quote here from Rollin's History of Egypt a brief description of that country in flood and harvest time, and some accounts of the quality of the water of those receded floods and the water of the Nile:

"There cannot be a finer sight in nature than Egypt exhibits at two seasons of the year. In the months of July and August, if a traveler should ascend some mountain or one of the far-famed Pyramids, he would behold a vast sea, in the midst of which numerous towns and villages appear, with several causeways leading from place to place, the whole interspersed with groves and fruit trees, whose tops only are visible. This view is bounded by mountains and woods, which terminate at the utmost distance the eye can discover the most beautiful horizon that can be imagined. On the contrary, in January and February, the whole country is like one continued scene of beautiful meadows, whose verdure, enamelled with flowers, which charms the eye. The spectator beholds on every side flocks and herds dispersed over all the plains, with infinite numbers of husbandmen and gardeners. The air is then perfumed by the great quantity of blossoms on the orange, lemon, and other trees, and so pure that breezes more salubrious or agreeable are not enjoyed in the wide expanse of creation."

That beautiful and perhaps exaggerated description of the salubrity of climate, and the fertility of soil and beauty of enchanting Egyptian scenery, would be no exaggeration of all those splendid advantages and inestimable pleasures to be ever enjoyed in this beautiful city and its vicinity.

In the land of former wisdom, the commencement of civilization and of vanished greatness, humble man is very grateful to his God, and thankful for the humblest of his gifts, and apparently well satisfied with his perfect work as he found it.

Here are more descriptions of the excellence of the water of the Nile, notwithstanding the fact that it washes down the alluvial soil which fertilizes the Soudan and the whole of Egypt, and drains nearly three thousand miles of territory:

Savary, in his "Letters on Egypt," says in a note, that "Ptolemy Philadelphus, marrying his daughter Berenice to Antiochus, King of Syria, sent her water from the Nile, which alone she could drink

(Athenæus); that the Kings of Persia sent for the waters of the Nile and sal ammoniae (Dino, History of Persia); that the Egyptians are the only people who preserve the water of the Nile in sealed vases, and drink it when it is old with the same pleasure that epicureans and wine-bibers do old wine (Aristides Rhetor)."

The same author also bears his own testimony to the agreeable qualities of the water of the Nile. He says: "The waters of the Nile, also lighter, softer, and more agreeable to the taste than any I know, greatly influence the health of the inhabitants. All antiquity acknowledges their excellence, and the people certainly drink them with a kind of avidity without being injured by the quantity."

Maillet is more enthusiastic in his description of the Nile water, affirming that when a stranger drinks it for the first time it seems like a drink prepared by art, and that it is among waters what champagne is among wines.

There is no special superior quality or particular virtue ascribed to the palatable waters of the Nile by its most enthusiastic admirers that are not possessed to a larger extent, and in a much higher degree than the Nile, or any river in the world, by the wholesome water of the Sacramento River, as has been proven beyond a peradventure or possibility of a doubt by every honest, capable, and impartial chemist and bacteriologist who has thus far been called upon to test its condition or qualities, which the following chemical analysis will or should prove to the satisfaction of the mind of the most skeptical:

	Gr.
Carbonate of soda, per gal	0.27
Chloride of sodium, Sulphate of sodium	1.42
Carbonate of lime	2.31
Carbonate of magnesia	0.25
Silica	1.85
Sulphate of lime	0.42
Phosphate of lime	1.48
Iron and magnesia carbonate	0.63
Alumina	0.07
Vegetable matter	0.00

Notwithstanding the contrary opinion held and proclaimed to the world by a few wiseacres, corporation scribes and other mercenary lackeys, I could go on describing thousands of large and populous cities until I could fill a work of several volumes, all of which are built on rivers and take their water supply from the rivers upon which they are built. I merely desire to mention enough to satisfy the minds of the people here that they are receiving the best, the cheapest and the most wholesome water on earth, as also to intimate to them that there is a sordid motive underlying all this campaign against and condemnation of the health-preserving water of the Sacramento river, by men, the value of whose opinion and judgment should not be considered, or even tolerated for a moment by any sensible man or woman who value their health or lives and those of their families and friends as being worth anything at all.

If they would observe the results of this advice on their neighbors when the families or friends and patrons of these deeply-learned, anti-river-water doctors are afflicted with sickness of any character, from a boil on the ear, a wart on the cheek, a felon on the finger, a corn on the toe, or an ingrowing nail, and one of these wise doctors is called in to diagnose the case they could satisfy themselves that they have been misinformed concerning the wisdom of these wise and all knowing doctors. Upon his arrival at the home or dwelling of the patient he looks learnedly wise, divests himself of one of his wine-colored gloves, adjusts the other and assumes a sympathetically and seriously grave aspect—"ah! ah!"—feels the pulse of his patient, becomes very pensive and finally requests this victim of misplaced confidence to extend his or her coated tongue apast his or her fevered lips. "Do you drink well or river water?" He receives the terrifying answer with fear and awe—"I drink river water." "Do you boil it?" "Yes, doctor. You remember you told me over a year ago to be sure and boil the water before using it or giving it to any of the family to drink. You said at the same time these typhoid germs which you were sure were generated, prospered, grew fat and were multiplied by the billion in the Sacramento river would, by boiling them to about 300 degrees Fr., not only become harmless, but very nutritious." "Well," said this erudite, esculapian sage, "I really believed this precaution a positive and specific preventive of typhoid fever." His royal nibs said no more, but still continued silent, looked wise, without even acknowledging disappointment at not only the vain but opposite result of his precautionary, experimental advice, for the very reason that it was not the first time that he and his patients were disappointed in his prescriptions.

To this new made graves, the elegant and costly marble and granite tablets and monuments and the surviving relatives of their misled, silent victims can testify.

It is a most glaring but irrefutable fact that there is scarcely a family or an individual in this city suffering from biliousness, ague, malaria or any species of fever who are not the misguided subscribers for well water or the drinkers of boiled river water, as I am personally acquainted with half a dozen families who have not drank any other but boiled water for years past. And from one to three members of these families have been smitten with this epidemic they call, or are pleased to call, typhoid fever, and which some very eminent doctors here say are only heavy cases of malarial fevers. The same is true of families who drink well water in this city, of whom there are quite a number residing in the northeast of town, where the city water mains have not yet been extended. They all have clear water to all outward appearances, yet they are nearly all complaining of various species of low fevers, ague and biliousness, and are constantly inquiring of city officials how soon the city will be able to extend the water mains in that section of town, or if they could inform them where they could rent a cheap house within the radius of the present water mains of this city I know a business man of this city who did not like the looks of the Sacramento river water when he first came to reside here, and for the first two years of his residence in this place he suffered from malarial fever constantly, and feared he would be obliged to return whence he came, until his wife told him as a last resort to drink the city water freely. He took her advice, and as a result has not been troubled with malaria ever since.

This is the actual experience of all residents of this city, which was one of the most unhealthy cities in the State until the water works were built in 1854. It had been the breeding and abiding place of malarial fever, ague, and even cholera, which fearful disease became an epidemic scourge in this city, decimating its inhabitants in that never-to-be-forgotten year of 1852. But immediately succeeding the construction of the municipal water works and the extension of the mains through the then young and thriving city, those low fevers and other epidemics vanished as certainly as do the snows of Winter beneath the burning influence of a midsummer sun.

This is the practical experience of mankind since the development of his civilization commenced. It is the experience of every country on the earth, as well as every State of this great American Union. Some of the latter I mention here for information and the benefit of the credulous, misled people of this most falsely represented community. In Ohio, Illinois, Iowa, Mississippi, Pennsylvania, New York, New Jersey, Massachusetts, Rhode Island, Maine, and in nearly every State of this Union, where well water could be procured, or artesian and other wells, lakes, etc., were ordered closed by the constituted authorities, Boards of Health and all public officials, and the river water substituted therefor immediately. Hear what Mayor Charles A. Collier, the City Chemist and Bacteriologist and Board of Health of Atlanta, Ga., have to say on this subject:

MAYOR'S OFFICE.

CHAS. A. COLLIER,
MAYOR.

ATLANTA, GA., June 24, 1898.

HON. JAMES H. DEVINE,
City Trustee, Sacramento, Cal.

Dear Sir: Replying to your communication of the 17th inst., I send you by this mail, under separate cover, copies of the annual reports of our Board of Health and Board of Water Commissioners for the years 1896 and 1897, the portions of which bearing upon the subject you write about I have marked.

At our elevation—1100 feet above the sea—as fast as water mains and sewers are extended into districts without them all wells are condemned and ordered filled up. Some years ago an artesian well was sunk here to a depth of 1700 feet and furnished an abundance of water flowing to within ten feet of the surface, but this well was abandoned because the water became contaminated. Atlanta has a most excellent sewerage system, and the country is rolling, but notwithstanding this well water is extremely dangerous. About 95 per cent. of all the typhoid and scarlet fever and diptheria cases occurring within the last two years originated from the use of well water. This is shown by the records of the Board of Health.

Our water supply comes from the Chattahoochee river, a stream that is always muddy, but after the water passes through our settling basin and the mechanical filters at pumping station No. 2 it is served to consumers perfectly clear.

On October 5th of this year we will have a water bond election, and, if the result is favorable, the money arising from the sale of the bonds is to be applied exclusively to the completion of our system of water mains, so far as is practicable, and all wells along the extensions will be condemned. Very respectfully,

C. A. COLLIER, Mayor.

The report of the Board of Health for 1896 in the city of Atlanta, Georgia, says:

It is not only wise for the city to prosecute vigorously the work of extending water mains into every street, in a business point of view, but such policies are dictated by the highest views of humanity. I have before me a very interesting work by Mr. James A. Fuertes, a high authority as a civil engineer and sanitarian. He gives a diagram made in 1894 or in 1896, comprising many of the principal cities of the world, including Atlanta, from which it appears that the death rate from typhoid fever per hundred thousand inhabitants that year in Atlanta was 150. The table Atlanta shows that year by year until 1894, and at that date a steady decreasing ratio. The rate of deaths from typhoid fever in our city had fallen to 43 per 100,000. This improvement is attributed to extension of the water mains and to improvements in the character of the water. The repeated conclusion reported by the Board of Health, with most overwhelming and convincing statistics gathered by that body, shows that in almost every instance where typhoid fever or other zymotic diseases occur in our city is attributable to the drinking of well water.

The report of the Board of Health of Atlanta, Ga., for the year 1897, says: "Atlanta is blessed with the purest and most abundant water supply of any city of its size in the United States. Notwith-withstanding this fact, many of her citizens are drinking water which is nothing more than diluted sewerage, from wells that are little better than cesspools. The Board of Health most earnestly calls the attention of your honorable body and the community at large to the danger of drinking well water in the old and thickly populated portions of the city—those adjacent to open drains and water courses into which sewers enter. About 90 per cent of all the cases of typhoid fever have occurred in those who habitually drink well water.

"This, in connection with our abundant and pure water supply, emphasizes the necessity for constant watchfulness and frequent analysis of well water used for drinking and domestic purposes, and the immediate abandonment and filling up of all wells which show evidences of pollution. Atlanta owes it to her citizens to extend to all of them as rapidly as possible the benefits of her abundant and pure water supply."

In the course of my inquiries and investigations of this most important question of drinking water, which has been so freely and unfairly agitated for the last five years past, and still continues to be brutally, disgustingly and bitterly discussed in this city by a certain set of irresponsible and evidently incompetent persons; but, perhaps, and it is to be hoped and believed that some of them at least are very well-meaning people and, therefore, are carried away more by their uninformed and delusive imagination than any sordid motive, scientific or practical knowledge they have acquired by experience or investigation of this question, which, of all others, most affects and, therefore, should most interest the human race. I visited the Protestant Orphan Asylum for the purpose of ascertaining from what source they received their water supply and its effect on the health of the inmates of that institution, as I concluded it would be a most valuable criterion and an object lesson as to whether the river water is the disease-breeding, typhoid-germ-charged death-dealing poison certain impracticable doctors and mercenary newspaper men charge it with, and claim it to be responsible for all the malarial fevers, typhoid, and in fact all other sickness which was and is prevailing here thus far this year of abnormal drought with all its usual trains of misfortunes, poverty, disappointments, fear, epidemic sickness and death. And, just as I expected, they use only Sacramento river water straight, which simply means that it is neither filtered nor boiled. The doctors who attend to the medical necessities and health of the inmates of that institution may or may not be of the opinion or belief that filtering materially improves the water supply for the children. The fact remains that they have not had a single case of typhoid fever this year among the hundred and forty-five inmates of that public institution, besides the help necessary to take care of and manage such a large number of children, all of whom are under 15 years of age. And it is also the strongest and most incontrovertable evidence, not only of the superior quality and wholesomeness of Sacramento river water, but it is also irrefutable proof of the falsity, ignorance and incompetency of those who would substitute the poisonous contagion of the sewerage of the city and the drainage of the dairies, pig-pens and cow pastures of the suburbs of town in the masked form of clear well water, which is only a cleared conglomeration, not only of all the above filth, but it is also impregnated with salts, alum, alkali and other mineral, vegetable and organic poisons.

It is also a dead and death-dealing water, by the drinking of which the misled and helpless people of this city will be subjected to, and may possibly become, the innocent victims of typhoid fever, malaria, ague, and other fevers, cramps in the stomach, and even cholera, which those who are drinking the vile decoction are now suffering from, and are drinking it upon the recommendation of their doctor, who is wise beyond all comprehension, and therefore an indisputable authority, not only on the different qualities of drinking water, but all hygienic science. Therefore, it would be an insult to the exalted intelligence of some of the corporation water and other combine hand circulars, who pose and even prosper in this community as newspapers, to dispute with those very learned, extensively traveled, practically experienced, all-wise doctors, any theory they may advance, no matter how wild, incompetent, inapplicable, incomprehensible, or incorrect they may be.

These alleged newspapers ever claim to be the exponents of justice and fair play for the people; the sleepless and tireless advocates of their liberties, rights, and interests, and of the progress, growth, and prosperity of their own most favored city. The false representations, vicious, lying, advertising, false editorial descriptions of the water supply of this city, which have been most industriously and deceitfully worked up and published to the world from time to time, but regularly since 1893—the year they agreed to deliver the water supply of this city from the ownership of the people to that of a private corporation—and that they never fail to abuse those who opposo that gigantic robbery is in evidence of the villainous hypocrisy of those self-satisfied, sanctimonious Iagos of nineteenth century methods.

I desire to inform the victims of drinking boiled ice water and their evil advisers that the common sense, practical doctors who attend the public institution which I accepted for my information, criterion and guide on this question of the difference between well water, boiled river and filtered water and river water straight, have reached the conclusion, and they fully realize that boiling the water deprives it of its most nutritious and health imparting properties. Boiling eliminates from it by precipitation the lime which makes and sustains bone and tissue, and evaporates from it the air and carbon which an all wise Creator placed there to serve a good and useful purpose. But when this wholesome river water, already prepared and purified by the inimitable hand of Nature, is debauched by the advice and under the direction of a few medical and other windy microbe maniacs, to whose folly and partial insanity the attention of the State Board of Health should be called at once, it becomes an unknown, dangerous and health-menacing substance; therefore, the physicians in charge of the local public home for orphan children do not allow the water boiled, nor do they allow any sewerage, contagion, alkali or other poision-bearing water to enter the precincts of a public institution over whose health, lives and well being they are the faithful guardians, which accounts for the excellent health of its inmates and the fact they have had but one death in seven years among one hundred and fifty children under their charge. It cannot be denied that this is as good a showing as can possibly be made by any similar public or private institution in the world.

And if it is not sufficient proof of the falsity of the charges made against the river water, and claims which have been made and are being made that it was and is surcharged with microbes and the bacilli of typhoid fever and the germs of many other diseases, then it is a most vain, hopeless and difficult undertaking to convince the gullible people of this oft-deceived and case-game buncoed city of the facts of a question which not only involves the most vital interest of themselves and the welfare of their own beautiful city, but one which is of the greatest importance to the whole human race.

CONFLICTING TESTIMONY.

Hear what the State Board of Health have to say on the difference between well and river waters through their Secretary, Dr. Thomas M. Logan, one of Sacramento's most learned, experienced and distinguished doctors of early days. Peace to his honest, practical and truthful soul. The letter follows:

To the Hon. John Domingo, Chairman of the Committee on County Hospitals:

SIR: I herewith present the following report respecting the three samples of well water, numbered I, II and III respectively, and submitted to me for an *ex officio* opinion as to fitness for the uses of the County Hospital.

Few sanitary subjects are deserving of more attention than that relating to potable water. Owing to its great solvent powers, water is never found perfectly pure in any place. In some mountainous and mining districts it holds in solution minute traces of heavy metals, and in its course through the various strata of the earth's crust it, not improbably, sometimes obtains those salts arising from "fossil sewage" which, in the early geological ages, were deposited as organic matter. Certainly, in cities and towns whose water is procured from wells, it becomes contaminated more or less with impurities from the soil, from sewage, from house drainings and other channels of a like nature. In general, the impregnations acquired are not sufficient to give it any very sensible taste or odor to render it unfit for ordinary domestic purposes; nor does the presence of chlorates, hydrates or sulphates necessarily prove, in all cases, defilement by the perfect decomposition and full oxidation of previous sewage contamination; but to be declared absolutely safe for drinking purposes water should be perfectly free from the minutest trace of nitrogenons matter, because the presence of the above mentioned salts, if accompanied by these matters, would indicate that organic substances were now actually being in an active state of decomposition, when the water is in the most dangerous condition.

In order, therefore, to form an opinion of any value respecting any given water the necessity of first obtaining an analysis, in accordance with the extended views of what deleterious impregnations imply, becomes obvious. For this reason I applied to certain experts in San Francisco for an analysis of the water in question, but, finding the fee demanded (one hundred dollars for each specimen), although only reasanable, still altogether beyond our calculations, I proceeded, with the chemical assistance of Mr. J. F. Rudolph of this city, and the Rev. Dr. J. H. Wythe, who kindly volunteered his valuable services with the microscope, to subject the samples of water to such examination as will, I feel confident, answer all the practical purposes required. The following are the results:

Number one, specific gravity, 1,000.82 completely decolorized permanganate of potash in about twenty-four hours, when used in the manner recommended for the detection of organic matter by Mahony. The amount of fixed saline residue was seven and a half grains to the gallon of water.

Number two, specific gravity, 1,000.00 scarcely affected the permanganate color, and at the end of two weeks was but slightly changed. Amount of fixed saline matter, about the same as number one.

Number three, specific gravity, 1,000.51 completely decolorized the permanganate test in a few hours. Amount of fixed saline matter was equal to ten grains to the gallon.

The analysis being qualitative only, no attempt was made to isolate the various ingredients, but merely to ascertain the probable constituents. The tests used showed the presence of carbonic and sulphuric acids, and chlorine in combination with lime, soda and magnesia and potassa as basis.

The specimens were all clear, transparent and crystalline in appearance to the naked eye.

Submitted to the microscope, water number one exhibited traces of algoid vetetation. The sediment insoluble in alcohol showed a saline deposit, chiefly chloride of sodium.

In number two a few vegetable filaments, and also a broad film entangling spores of fungi were visible. The insoluble sediment was of the same character as number one.

In number three were plainly seen a small quantity of decomposing vegetable matter, also spores of algæ, some free and others germinating. Some oscillatoriæ were alike discernible. Sediment same as the others.

From the above results we are led to the conclusion that, while the water of numbers one and three are sufficiently soft to be suitable for washing and bathing, they are neither (particularly the last) fit for drinking and cooking. Not only would there be some risk of the mineral substances held in solution acting injuriously upon the stomach and kidneys, but the decomposing organic matters might induce such a state of the system as would aggravate every constitutional tendency to disease, and cause the inmates of the hospital to fall an easy prey to typhoid and other maladies of a low grade.

The water from number two is of considerable purity, and will compare favorably with that supplied by the Sacramento River. To afford some opportunity of comparison, I herewith introduce an analysis of the water made in April, 1857, by Dr. James Blake, now of San Francisco. One hundred and twenty ounces, taken from the river at the height of the freshet and evaporated to dryness, left a residue which weighed two and fifty one-hundredths grains. This consisted of:

COMPONENTS.	GRAINS.
Sulphate of lime, or gypsum	1.27
Sulphate of magnesia, or Epsom salts	0.70
Chloride of sodium, or common salt	0.21
Silicate of potash	0.13
Silica	0.25
Iron	a trace
Loss	0.03
Total	2.50

From this analysis, which differs somewhat from the results obtained by us during the present very dry season, it would appear that the average amount of soluble material contained in our river water is but one part in twenty-three thousand. In each glass, therefore, only the eighth of a grain of saline constituents are present, and this small amount is almost inappreciable in its effect upon the animal system when unaccompanied by decomposing organic substances, as we find it to be. In fact, if these salts exert any effect they are beneficial and not deleterious. From these statements it would also appear that our Sacramento river is even purer than that of the Mississipi, which has a world-wide reputation for salubrity; for, in an analysis by Professor James Jones of New Orleans, reported to General Baxton Bragg, I find he puts down the proportions of saline constituents in each glass of this water at half a grain.

While reprehending, therefore, the use of water containing an excess of mineral matters, I cannot but coincide with those sanitarians who affirm that water of moderate hardness, *ceteris paribus*, is always to be preferred to that which is entirely soft. So well satisfied are the French authorities of the superiority of hard water, that they pass by that of the sandy plains near Paris and go far away to the chalk hills of Champagne, where they find water ever harder than that of London, giving as a reason for the preference that more of the conscripts from the soft water districts are rejected on account of want of strength of muscle than from the soft water districts, from which they conclude that the calcareous matter is favorable to the formation of the tissues. Nor would I object, from a hygienic standpoint, to the suspended matters found in most of ours river during a freshet, which, consisting chiefly of silicates and clayey matters, give that turpid appearance to which a general aversion is manifested.

I am pleased to be able to state that I am sustained in this opinion as to its harmlessness by Professor Jones. "The suspended matters," he states, "so far from rendering the water of the Mississippi river unfit for sanitary purposes, add to their disinfectant properties. The health of New Orleans would be, without doubt, greatly promoted by flushing out the main drains and gutters continuously with full streams of river water. The mud which would settle along the sides and bottoms of the drains would possess no noxious properties whatever, of itself." This system was adopted while New Orleans was held by the Federal armies during the late Civil War, and the city never was healthier.

Reviewing the whole subject in all its bearings, I would recommend you to look rather to the supply of water for the hospital ultimately from the river, when the Holly system of filtering and distribution shall have been perfected, than to the precarious supply of water from the wells, however pure it be shown to be by analysis at any one time. Seasons and a variety of other circumstances, as has just been stated, respecting our river water, do certainly produce effects at certain times that may not exist at others. The water of any locality might be deemed harmless at one time and soon after the same water, although containing but a minimum of organic matter, may be found to possess organized matter of such a deleterious nature that our ideas of the most virulent substances fall short of the horrible results that these invisible poisons can accomblish. From the absence of proper drains refuse poured upon the ground may infect water just as it does air. In some instances the kitchen slops, delivered from a spout upon a limited space have, in the course of time, worn a direct channel to the family or neighboring well. In any case, it must be remembered that the soil surrounding a well is drained by it. It is stated by high authorities that the soil and sub-soil surrounding is drained by it, and that the extent of the drainage may be represented by an inverted cone, of which the base at the surface of the ground is equal to from one to three times the depth of the excavation, this difference depending on the porousness of the earth.

From this it will be seen how important it is that pig-sties, privies and manure heaps should be kept at a certain distance from habitations of all kinds. Many a case of impaired vitality, ready to succumb to trifling ailments, might be traced to such pollution. The disinfecting quality of earth itself fortunately relieves us from this greatest liability to impure well water, but even this beneficial quality may be exhausted by abuse. In certain localities, near the borders of rivers, wells sunk in the beds of sand and gravel yield good water, which percolates through from the river; but a few feet will frequently alter the character of the water entirely. For this reason, too much thoughtful care cannot be given to the construction of the proposed wing-dam cistern in the bank of the Sacramento River, in carrying out the Holly system of supply. All of which is respectfully submitted.

THOMAS M. LOGAN, M. D.,
Permanent Secretary State Board of Health.

"But," say those local anti-river, so-called scientific, medical, bug and water experts, and their scientific, corporation, sanitary scienced, conceited, conniving dodgers, posing in this community under the deceptive garb of daily newspapers, "conditions have changed greatly since those days. For instance, there are now a thousand convicts in the State Prison at Folsom, and there are more people living on the American River than there were in early days. And, therefore, the chances of polluting the water of the Sacramento River are greater than then." Which charges are about in line with all the arguments those gentlemen have advanced since their disappointment in the bold attempt of the greedy water pirates, their scheming doctors and newspaper allies to posess themselves of the ownership of the municipal water supply of this city in 1893, without giving the people a single dollar in compensation therefor. And the total robbery of the people was to have been consummated then, as now, under the cunning disguise of sparkling clear water from the east of town.

THE FALLACY EXPOSED.

In reply to this oft-repeated and time-worn fad of the virtuous and enlightened army of the water combines and lackey experts, I respectfully remind them that there is not to-day on the American River and all other creeks and tributaries of the Sacramento one person to every five hundred who dwelt and operated mines on those rivers, creeks and tributaries of the Sacramento River in the early fifties.

There is a very prominent and most reliable gentleman now residing in this city who informs me there were 700 votes polled in Mormon Island, on the American river, in 1852, and about three times that number in the town of Folsom. Allowing four persons to each voter and multiplying the above number by four, we have in round numbers 11,200 people in those two little towns alone, and in the former of which cannot be found three families to-day, besides the thousands of other mining camps, which were in full and profitable operation in those days on all the tributaries of the Sacramento river. Hence the pollution of the water of that river was, at the very lowest estimate, a thousand times greater when the water works were built in this city in 1854, which have brought health and comfort to its people and saved them hundreds of thousands of dollars by obviating the possibility of being half their time sick and paying large fees to the learned and sympathetic doctors during their time of partial health. Hence the advice of some of those all-wise philanthropists to return to the good old days of wells, ague and all species of low fevers—and heavy feed, wealthy doctors. And, to be sure, nature's social, economic and all other laws must be subordinated to satiate the greed of the shrewd, masked water and other thieving combines.

I presume the deeply-learned medical and newspaper water experts and their falsely-educated and misled dupes will not only deny, but endeavor to reverse in order to sustain their false attitude on the water question, the inimitable plan of the Creator in the simple and peerless means adopted at the beginning of time for maintaining the perfect purity of the almost boundless ocean, seas, straits and bays of this broad earth; and into which not only the diseased and putrid carcasses of cattle and hogs which die of hog cholera, but all species of live stock and wild beasts which die of all diseases known to experience and medical science, but hundreds of thousands of human bodies are buried in those waters annually who die of all sorts of diseases; besides, they carry off into their boundless wastes all the putrid filth of the earth.

Yet, notwithstanding these waters being the dumping ground for the offal of over 3,000,000,000 human beings, many of whom are still in a primitive state, and consequently very filthy, yet those waters are absolutely pure, and upon their friendly surface the air is purified and charged with a balmy ozone, which invigorates, promotes and brings good health to the human race as it is wafted over the whole earth—to the poor and the rich, the depraved, the vile and the virtuous, the honest man and the schemer, the wicked and the just alike, in the bountiful wisdom of an impartial, ever-merciful and just God.

I hope, upon due reflection, my learned anti-river drinking water friends will admit that it is not the amount of salt in those immense and measureless bodies of water that keeps them perpetually pure and by which they purify the atmosphere also. No, gentlemen, the same means are applied in accomplishing this wonderful work that is perpetually taking place in rivers to purify the boundless waters of the ocean. These are agitation, motion, travel and exposure to the sun and air, which are the principal factors in the purification of water. Notwithstanding the unreasonable vaporings of the advocates of corporation ownership of the water supply of this city, who are continually blowing their mercenary horn and trying to impress the good people of this bond-fleeced city that they are the only people in the universe who are using river water for drinking. I will respectfully mention, for the edification as well as by way of adding something in general to the limited knowledge of the sycophants of a greedy, would-be Sacramento water monopoly, a very few of the many thousand American cities whose people live in luxurious health on the banks of very muddy rivers. For instance, there are the cities of Omaha, Jefferson City, Atchison and Nebraska City on the Missouri River; St. Paul, Dubuque, Quincy, St. Louis, Davenport, Vicksburg, Natchez, New Orleans and many other populous cities on the Mississippi River; Cincinnati, Covington, Evansville, Louisville and many smaller towns and cities on the Ohio River. And all over the United States, Europe and the world, nearly all cities are built on rivers, and the people of those cities are supplied with drinking water from said rivers. The three American rivers which I have named take in more sewage, dead hogs and other carrion and decaying vegetable matter and all sorts of unmentionable filth than have been dumped or have found their way into the Sacramento River since the discovery of America and a thousand years before that time.

But a few of the alleged doctors and corporation-phonograph newspaper lackies of those cities are not maintaining a corps of lying detectives for a distance of two hundred miles on those rivers to make entry of all the cattle, horses, sheep and hogs that go there to drink and are drowned in those rivers, and exaggerate the number and claim that those animals died of all species of diseases, from glanders, tuberculosis, to hog cholera, as do the two daily dodgers of the water pirates of this city, who make it their business to publish such statements from time to time that they may succeed in disgusting the deceived people of this community with the present wholesome water supply. These subservient blatherskites would be enabled to earn a large fee by transferring the ownership of the water supply of this city from the people to the capacious maw of the avaricious highbinders, with whom they evidently entered into a contract in 1893 for the accomplishment of that nefarious robbery of the people of this city, about whose health and prosperity those medicasters and scandal-monging philanthropists pretend to worry so much, and to secure which for the dear, good people seems to be their only desire or ambition to live. To be sure, the aforesaid dear people never dropped onto a little joker contained in that cunningly conceived contract to the effect that when those elegant gentlemen of the party of the second part did not have an adequate quantity of water at their pseudo wells east of town they would supply the people with water from the municipal water works at slightly reduced rates, which was the original intention and secret of the whole thieving, stand and deliver conspiracy. And as soon as the well-put-up job was consummated, the subservient vassals of corporation rapacity would immediately change their tune and harp the strings of truth so long as it suited the money-getting interests of their owners and masters, by expatiating on the pure and superior qualities of Sacramento River water, in which they would be absolutely correct, and could not be successfully contradicted.

SACRAMENTO RIVER WATER AND THE WATER SUPPLY OF OTHER CITIES.

I cite here for the benefit and information of the very tolerant, long-suffering and patient people of this community a few more facts comparing their city's pure water supply with other less favored cities, which should convince them of the selfish and sordid motives actuating those unprincipled, dangerous men, who have made and are still waging a fierce and bitter campaign against it in the interests of the masked thieves who planned, plotted and schemed to possess themselves of its ownership.

The city of Calcutta, on the great river Hugely, with a population of about six hundred thousand people, and with hundreds of tributaries of that river in far away India, where millions of people live on its fertile and fertilizing shores, and where not only the sewerage of those millions are carried away by that river, but it is claimed that hundreds of thousands of the mountain tribes and residents of the Himalayas, on the banks of said river and its tributaries, neither bury nor cremate their dead, but instead drop them into that river, from which not only the people of Calcutta, but millions of other people are supplied with water for drinking and culinary purposes, and those people are comparatively healthy, except when they are suffering from the ravages of famine, which almost invariably produce pestilence and plague in the best regulated countries.

And Philadelphia, one of the largest, most populous and important cities in the United States, with over a million inhabitants, receives its water supply from the Schuylkill River, which has not half the velocity of the Sacramento, and which is only a hundred and ten miles long and is navigated by canalers and other boatmen. And, certainly, canalers and boatmen are not considered the cleanest people in the world.

There are many populous cities on the banks of the Schuylkill, the inhabitants of which number, in the aggregate, over seven hundred and fifty thousand people, the sewerage and drainage of all of whom is carried by said river on its way to the Delaware, its intersection with which is several miles south of the water works and reservoirs supplying that city with water for all domestic purposes. Consequently, if it is, as our great newspaper water experts claim it to be, surcharged with heavy, coarse detritus, it reaches all Philadelphia's water pumping stations with all the pollution of the Schuylkill, upon whose busy banks are operated a thousand factories, consisting of dye and chemical works and all sorts of manufacturing enterprises.

Still, notwithstanding all these obnoxious contaminations, there are no mercenary subsidized newspapers in that fair city of homes and brotherly to constantly remind its people of these offensive facts, or keep ever before their minds and the minds of the outside world that the good people of the city of brotherly love were drinking foul, disease-breeding sewerage and death-dealing water from their convict prisons and thousands of other sources of drainage which would add to the pollution of their water supply, and thus frighten away outside investment of capital and the possible increase of population from the country and other less favored cities, as well as to disgust the people of their own prosperous and progressive city with their abundant and healthful water supply, by the use of which they are enjoying health and contentment of mind. But there are no private parties, nor water combines, in Philadelphia bold enough to undertake to steal the water supply of that city. Nor is there any Mayor nor Board of Aldermen daring or treacherous enough to assist in the consummation of the nefarious plot to make their confiding fellow-townsmen the unsuspicious and unwilling victims of a water monopoly similar to that of San Francisco and Oakland, where the price of water is supposed to be regulated by the cities' Board of Supervisors and the City Council, an instance of whose judgment and integrity the people of this State have been shown in this year of grace, 1898, and by which the people of this and other communities have been shown the danger of private or corporate ownership of the water supply of any municipality.

The taxpayers of this long-suffering city must never lose sight of the fact that, should they have the misfortune by any accident, error of judgment, or under any pretense, disguise, or offering of sparkling clear water to be supplied by any aggregation of water brigands and to be delivered just outside the city limits from alkali wells, lakes or streams, by which they would lose ownership, or any part of ownership in their water supply, they will be subjected to similar exacting conditions to those which the greedy water corporation cormorants impose, such as those by which the helpless people of San Francisco and Oakland are being fleeced and forced to pay tribute for the most inferior quality of water perhaps in the United States. The people of those cities are obliged to pay more for water than they do for bread. In Oakland, previous to the advent of the competitive water company in that city, a house of three or four rooms, such as this city supplies with water for 50 cents per month for all the occupants require and which is not measured out to them through red tape, cheating, corporation meters, would cost not less than a dollar and a half a month. A house of six rooms, which this municipality supplies with abundance of good and absolutely wholesome water for $1 per month would cost in Oakland from $3 to $5 per month, and in San Francisco the price of water is nearly as high.

THE DANGERS OF PRIVATE OWNERSHIP.

I shall prove to the good people of this city that the consummation of that Abbott-Henry conspiracy would have produced similar conditions in this city, and that every factory, stable, brewery, business house and all the beautiful homes in the residence quarters of this fair city would have had water meters placed on their premises for the purpose of measuring it at a stipulated price per gallon, just as gas is now sold. As the liberal terms offered by the Abbot-Henry water combine made the difference so great in the cost of pumping the water supply by that philanthropic combination that it would have become imperative to measure out the water to the people, as they had no conception of the enormous robbery contemplated by that, reputed to be, generous contract, which would have made a difference between what it is now costing the city and the cost under that contract of not less than $60,000 per annum, which difference would increase in proportion to the increasing demand for water. In proof of which, the average cost for pumping per million gallons in 1896 amounted to just $8.50, and still less in 1897, while with another modern ten-million-gallon pump, we can reduce the cost of pumping per million gallons to not exceed four dollars. As the average Abbot-Henry contract paid those gentlemen the comfortable sum of $29.00 per million gallons, it just makes the trifling difference between municipal pumping and contract pumping, which we were told, by the way, was so very favorable—in fact, a soft snap for the city—just $25.00 per million gallons, and, for an average of over two hundred millions per month, amounts to the snug little sum of $60,000 a year.

Notwithstanding this glaring fact, the truth-disseminating local papers brazenly proclaimed to the people of this city, the prospective and intended victims of the water combine, at that time that they were going to have the water delivered to them for absolutely less money than the municipal government was then furnishing it to the dear people, whose interests are always so carefully and faithfully conserved by those devoted and patriotic gentlemen, who certainly would not advocate, countenance or support any cunningly conceived job or conspiracy put up by any combine of schemers, organized under the banner of combined greed to extort money from the people. Nor would these honest and virtuous newspapers of this city espouse the cause of any, gas, electric light or water deal in the interests of private ownership, that they might have their hands and arms clean up to their elbows in the city treasury and might loot it at their own sweet will.

These gentlemen know very well when they claim that the contaminating surroundings and conditions of our water supply are the worst in the world that they are not telling the truth. Anyone who desires to satisfy himself on this important question can prove at very little trouble or expense by comparing the Sacramento River with any other river in the world supplying a city of the size and importance of this. Upon investigation he will learn that with all its windings the Sacramento River is nearly a thousand miles long; and that there is not a factory, nor more than fifteen thousand people residing upon its shores from its source to this city; and that it is not only the receptacle of nearly all the medicinal springs of the Coast Range, but also carries to our doors, refreshed and purified, the invigorating, health-giving waters of Mt. Shasta's inexhaustible mineral springs. Compare our supply with a few of Europe's largest cities, such as Berlin, Hamburg, Strasburg, Paris and London, all of which are built on the banks of rivers and receive their water supplies from rivers.

RIVER WATER THE MOST HEALTHFUL.

I want to show the people of this community, the intended victims of the water combine conspiracy, that it has been abundantly and most satisfactorily proven by experience, scientific, microscopic and bacteriological analysis and demonstration, that the waters of rivers are the healthiest and safest for the use of the human race and all animal life.

I quote some of the most eminent and reliable authorities to bear me out in this claim, commencing with Dr. Frankland, who placed the bacilli of typhus in the water of the Thames, and it disappeared entirely in from nine to thirteen days, while in the pure deep-well water of the Kent Company it survived for thirty-three to thirty-nine days. "The fact that excretory products of bacteria are inimical to bacteria themselves is the foundation of the process of inoculation against disease. It has been firmly established beyond the possibility of a doubt that organisms survive for much longer periods in soil, while they die off very rapidly in rivers, and even in sewers," where the purifying influence of the sun and pure atmosphere are absent.

I shall put the Royal Commission, who were appointed by the municipal government of London to examine and report upon the merits of the different waters, presented for the use of the five millions inhabitants of the great city of London, upon the witness stand, whom I hope will receive a respectfnl hearing, whose reports from 1892 and 1895 are as follows:

"We are strongly of the opinion that the water supplied to the consumers in London is of a very high standard of excellence and of purity, and that it is suitable in quality for all household purposes. We are well aware that a certain prejudice exists against the use of drinking water derived from the Thames and Leigh, because these rivers are liable to pollution, however perfect the subsequent purification, either by natural or artificial means, may be. But, having regard to the experience of London during the last thirty years, and to the evidence given to us on the subject, we do not believe that any danger exists of the spread of disease by the use of this water.

The report of same Commission in 1895:

"After all, the main evidence on which we have to base our judgment is that furnished by London itself for more than eighty years. The inhabitants of London have been drinking water from the Leigh and the Thames above Teddington, at points either the same as those at which the present intakes are situated, or at points where the chances of contamination were greater, and the population that has been thus supplied has varied from two and one-half millions to five millions. Here, then, we have an experiment on a gigantic scale, largely exceeding in compass the aggregate experience of all other places in which outbreaks of fever have been subjects of inquiry, and an experiment made, moreover, under the very conditions, or, at any rate, under no more favorable conditions than those that are still in operation in London.

"What has been the practical issue of this prolonged and wide experience? Every medical witness that has appeared before us, whether his general feeling was favorable or unfavorable to the water, has told us, unhesitatingly, that he knows of no single instance in which the consumption of this water has caused disease. This is the unanimous testimony of the medical officers of health, of the water analyists, and of the bacteriological experts—of all, in short, whose attention has been directed to the subject. The commission, therefore, thinks that the risk of disseminating disease, even by an admittedly polluted river water, under conditions similar to those which obtain in the Leigh and Thames, so small as to be negligible. No sane man can successfully dispute the fact that in nearly all rivers there is a great rapidity of purifying action constantly going on."

I cite for the benefit and possible enlightenment of the self-constituted and assumed newspaper and medical water experts of this city the perfect purification of a polluted river in a distance of less than thirty miles; this is the river Seine. After its becoming terribly polluted by the reception of the sewerage of two and a half millions of people and all their domestic animals, and the thousands of manufacturing enterprises of the great and busy city of Paris, on its sluggish course through that city, it steadily improves in appearance, and at thirty miles below that city it has been proven upon the most careful analysis to be actually and absolutely purer than it was before it received the horrible sewer of that populous city; and it must be remembered that the lands in Europe are very highly cultivated, and that stable manure, as well as liquid manure for fertilizing the soil is continuously used, and much of that filthy stuff finds its way into those rivers, which supply drinking water to most of the populous cities of Europe and of the world.

Yet, in the face of the fact that it has been proven to the entire satisfaction of the ablest physicians, scientists and most learned men in Europe and America, by the greatest and most experienced medical, analytic and chemical authorities on both continents that river water is purified by the action of Nature's own handiwork in a most incredibly short space of time and in every mile of travel on its course to the ocean, these anti-river water people decry the Sacramento on account of its receiving the waters of the American river, which carries the Folsom Prison sewerage. The Seine it is proven beyond a peradventure of a possible doubt to be perfectly purified in less than thirty miles on its course from the metropolis of France. And the conditions for the purification of the Seine are not within a thousand times as favorable in that country—or in any part of Europe—as they are right at home here with us, where such a thing as manuring river bottom land is unknown, and where nature supplies all the necessary properties of filtration and purification—such as rocks, pebbles, gravel, coarse and fine sands; besides, the velocity of the American river is very rapid, and the sun and atmosphere accomplish the final purification of that river.

Prof. D. T. Amstead, who has written an exhaustive treatise on "The Water Supplies of Towns and Cities," says: "Exceedingly clear water—water that approaches distilled water in its freedom from solid contents and gases—is not so well fitted for the supply of towns and cities as river water. Lead and salts of lead are to some extent soluble in such water, and may act as a poison, which, being cumulative, is insidious, and, if long neglected, may end in serious results."

The water sheds of Croton lake and river which supplies the great city of New York, and which has over two million people every working day of the year, drains more than twenty cemeteries and thousands of cesspools, privies and other contaminations, all of which are removed by the action of Nature on this water on its coarse to and ingress into that city. The same conditions prevail with the Passiac river, which supplies Jersey City, Hudson City, Hoboken and many more populous cities. But the daily newspapers of those places do not call the attention of the people to the filthy condition of their drinking water nor its horrible contamications in transit to their respective cities. No, the newspaper men of those places do not bend their energy for a stipulated amount of money to rob the people of the few public utilities still owned by their respective municipalitics, nor frighten away capital and proposed enterprise from their respective cities for the accomplishment of such nefarious ends by which they would depreciate the value of the property of their fellow citizens and retard the growth, progress and prosperity of their own towns and cities. Those were not the means employed to build up New York and other large American cities to their present splendid proportions.

Since the corrupt and corrupting, invisible gang of thus far disappointed water pirates placed their disease germ, microbe, scarecrow, darkly and deeply laid water robbery plot in the possession of their hired and subsidized, willing and most subervient lackies and newspaper horn tooters, they advised them to take advantage of the unfavorable conditions which ever result from dry seasons in low countries and semi-tropical climates, which are ever subject to ague, remittent, intermittent and other low fevers; and when these were raging all over this Coast, and much less affecting this than other sections of the State and Coast, they unfolded their campaign with renewed energy and vigor, which is only a continuation of the bold, stand-and-deliver plot of 1893, agreeable to the wishes of these suave schemers, said subservient lackies on what they believe to be a most cleverly conceived plan, put in full operation the preliminary work to the consummation of that theiving conspiracy of those masked, avaricious, top-loftical philanthropists. Hence the loud condemnation and denunciation of Sacramento River water as the recptacle of all sorts of animal and decaying vegetable filth and sewerage from the State Prison at Folsom, not only carrying all species of typhoid fever and other disease germs, but also the most destructive, contaminating and depraving criminal microbes, all of which find their way into the homes and thence into the stomachs of the inhabitants of this bond-conspiracy and water pirates doomed city, by way of the Sacramento River to be sure. So say the mercenary agents of those star-chamber conspirators, including the morning daily, general all around corporation echo, gold cornering, combine mouthpiece and advocate, and the daily evening bulldozer, subsidy-earning, winged microbe; and a brace of other less pretentious, more insignificant, nickle-catching, piece-making, weekly, monthly, yearly and eternal fakirs, who wage their uninformed, false, misleading and mercenary campaign against the wholesome river water, which has preserved the health of this city for forty-five years, and assisted to pay off a theiving bonded indebtedness, which has thus far cost the people and taxpayers of this city nearly $5,000,000, for which they never received any valuable consideration. This bond business was the result of a conspiracy, about in line with the unsuccessful water conspiracy, which was supported so ardently and energetically by those same patriotic alleged newspapers, who exist only to advocate and defend the liberties, interests and rights of the people, about whose safety they spend so many sleepless nights. Notwithstanding all their worry over the rights of said dear people, when the masked villians composing the water combine, who intend and are bent in the near future on owning the water supply of this city, gave out their corporation cue, under one disguise or another, the campaign against the present municipal water supply is renewed with seeming electrical power and energy. In a word, all the dark and deeply prepared, star chamber schemes of those philanthropists are dressed up splendidly in the innocent, white robes of humanity and philanthropy, and most plausibly presented to the unwary, timid, unsuspicious and ever credulous minds of the dear people, whom these magnanimous humanitarians intend to bunco, a la gold brick method, and through the medium of their hireling newspaper blatherskites, medicasters and other professional fakirs, and in the name of and for the love of humanity, which outwardly ever characterized corporation hypocrisy and cupidity, and by the shrewd manipulation and successful operation of this double-dealing, misleading policy. This up-to-date, gentlemanly parvenuceracy hope to own and control all the public utilities, and when they want to advance the price of said public utilities they need only to press a button and instruct their lackies to enforce their demands, and, if they are not immediately acceded to, this select, favored and high strung parvenuceracy are in a position to cut off all the necesearies of life from the toiling masses and all the rest of the dear people whom they love so much.

The alleged daily newspapers of this city have been and still are nauseously filthy in giving the people of this city and the outside world such a magnified, misleading and absolutely false description of the water supply in order to earn large fees promised them upon the consummation of the contemplated transfer of the ownership of the water supply of this city from the hands of the people to those of a private corporation by the conspiracy of 1893, failing in which these pseudo newspapers claim that they will see to it that broad-minded men will be elected to office in the future, who will be more pliable in their hands and subservient to their will and to the wishes of their scheme-hatching masters.

A MISLEADING BOARD OF HEALTH.

In view of the nasty campaign of falsehood conducted by these mercenary fakirs, and that the unreliable and disgusting rot emanating from their sanctums is not fit to be reproduced in print, I will give here instead some extracts from a newspaper report of a meeting of another set of faking philanthropists and posing philosophers known as the Board of Health of Sacramento, just to call the attention of the people to the impracticable and nonsensical ideas we are obliged to put up with and suffer from men pretending to be friends to the city's progress and learned hygienic experts. The headlines of the report of the meeting of this erudite body of water experts tells its own story and exposes to public gaze the ripe knowledge and storied wisdom of the learned sages composing the Board of Health of the Capital City of the great Golden State of California.

HEALTH REPORTS ARE WORTHLESS.

EVEN THE BOARD OF HEALTH SO CONCLUDES.

This statement is made by these Sacramento medical savants in support of a wild, vicious, exaggerated publication in the *Evening Tumblebug*, when it was positively known that there were but two cases of typhoid fever in this city, and which resulted from drinking well water. Said evening fakir multiplied and magnified said cases to over two hundred, and told the world that drinking Sacramento river water caused the fever epidemic in this city. And a certain member of said learned Board of Health said he believed there was at least a hundred other cases of typhoid fever in this city. And another of these pseudo learned gentlemen said he heard it remarked on the street that there could not be less than three hundred cases of typhoid fever in this city. These wild statements, unsupported by knowledge or truth, have been published to the outside world as facts The report goes on: "Dr. Henderson, like Dr. Ross, took a shy at the river water, which he believed to be the prime cause of the fever in a majority of cases"; and another wise and learned water expert microbe chaser and sure locater of disease germs, Dr. Ross, said he was willing to recommend to the Board of Education to use subterranean water at all the school-houses and to plug up all the hydrants for river water on the premises. In his wisdom and honesty of purpose he did not believe in being evasive in the matter, but to condemn the water at once. He thought this was the only safe plan to pursue. Dr. Fay thought it would be wise to compel the dairymen to furnish the cows with well water. Dr. Ross said that would be unnecessary, for cows were immune from typhoid. He thought, however, the dairymen should wash their cans and pans with well water.

Fellow citizens, hear two more of those learned sages, who are also members of your City Board of Health. The above manifestation of the profundity of their knowledge, learning, experience and wisdom certainly should recommend them to your consideration and induce you to extend them your patronage should fever or any other disease afflict your families, as your recovery would be speedy and the sad loneliness of death impossible, as those expert microbe anglers know just where to find them, and choke off the earth all those determined, minute, villainous assassins. In fact they know so much about them and their annihilating intentions that they summoned up enough courage to meet under a flag of truce their commanding officers, who are leading their innumerable hosts to the invasion and final destruction of our peaceful and inoffensive city through the Sacramento river. And by much scientific persuasion they secured favorable terms to the extent of guaranteeing immunity to cows from the attacks of the countless legions of the lionine carnivoracity of these invincible armies of gluttonous microbes, armed with the terrible, debilitating and destructive weapons of typhoid fever. And, therefore, since those magnanimous terms have been secured, our cows can drink Sacramento river water with impunity after it is filtered and boiled to about 300 degrees Fahrenheit. How singularly blest Sacramento City is, with such extraordinarily clever doctors and the far-seeing medical experts which constitute its City Board of Health.

These wonderful men, and their predecessors, informed the doomed people of this oft-gulled community that milk carried great armies of microbes and numerous species of disease germs and death-dealing animalculæ, the most dangerous and destructive of which is the tubercular tribe, each and every one of which is armed with knobs on their bodies as sharp as lances, and with which they were determined to wipe the good people of this community, and particularly its fairest, dearest, most interesting and promising babies from off the earth. In behalf of the babies, the Board of City Trustees were most pathetically appealed to by said medical philanthropists for the creation of the office of Milk, Meat and Market Inspector at a salary not to exceed $100 per month, but fitting up his laboratory and rent thereof will run the maintenance of this municipal, microbe chasing device up to a much larger sum than the amount first demanded by those wonderful and deeply learned animalcular experts and sympathetic self-sacrificing humanitarians.

The unselfish devotion of those medical philanthropists has manifested itself in a most substantial form, to my knowledge and experience in the last five years that I have enjoyed the honor of serving as a member of the Board of City Trustees before whom those gentlemen never made a plea in the interests of humanity either for the promotion or preservation of its health, or pretended prolongation of its life, that said appeal was not accompanied by a demand on the City Treasury for more money. And when said demand is allowed, sickness and the death rate increased proportionately, with the decrease in the Treasury. If we reflect on the ignorance of the ancients and all their successors, of the existence of the sportive microbes and all their accompanying evils, we of the enlightened 19th century are astonished to read of the millions of said ancients who engaged in war were slain in battle, and the millions who lived to a good, old age in blissful ignorance of the dangers to which they were exposed by the presence of those terrible, invincible enemies of the human race. And we are still more surprised in view of the many modern medical discoveries and the scientific safeguards which are so lavishly thrown around the human family that any of them die at all in this advanced part of the 19th century.

Those extraordinary far-seeing animalculists and scientific benefactors cost the inhabitants of this city, and county who only number, all told, 43,000, in salaries alone, monthly, the sum of $1452.66. To one set of presumably educated parasites, for protection and promised immunity from the invasions and vicious attacks of another immense army of low-down, carniverous and most destructive parasites to whom the educated set have given a very bad name. Our educated army of defense consists first, of the County Hospital, the salaries of which amount monthly to $842.66; County Veterinary and his Deputy, $150.00; City Physician and his Deputy, $160.00; Building and Sanitary Inspector, $100.00: Milk, Meat and Market Inspector, $100.00; Sanitary Plumber, $100.00.

Notwithstanding this great outlay and all the scientific and sanitary precautions poor mortals sicken and die just the same as they have ever since life commenced. And there are just as few old people to be seen now as there was a thousand or six thousand years ago. And doctors will continue to fill out certificates of death now, and in future, as they have ever since that practice commenced. It seems when Almighty God created mankind he gave him his eyesight and made it strong enough to serve all necessary and useful purposes and not to pry into the secret mysteries of His perfect being and wonderful work of creation, all of which seem to be founded upon animal life, and without the use and application of powerful magnifying glasses, some of which are now made so they can make an ordinary fly appear twelve miles long, by applying which to everything we eat and drink, we would bring so much of this low animal life to view that we would become so disgusted at their nauseating appearance that we would not eat or drink anything at all, and only sicken and die instead.

THE CASE OF SECRETARY SMITH.

Among the many water experts and learned microbe prophets who loaned his influence to the combine, anti-river water pirates' campaign of 1898, there are none who surprised me more, nor from whom a better argument in defense of Sacramento river water can be obtained than my esteemed friend, Edwin F. Smith, who, when he was comparatively poor like the rest of us, remained at home in this city nearly all the time, drank Sacramento river water straight, lived plain and simple. But he became rich and influential, and by slow degrees he sought and easily found other associates and other and maybe stronger waters to drink than plain and health-preserving Sacramento river water which, while he continued its liberal use without adulteration, the vicious typhoid germs never attacked his ample form, in which there is an abundance of room for the generation and propagation of all species of good, big, fat, energetic microbes, without innoculation from Sacramento river water or any other water. If Mr. Edwin F. Smith, the learned doctors and newspaper water and microbe experts of this city would kindly inform this credulous and confiding public where this destructive, cunning, typhoid fever germ first originated previous to the adoption of his educated and far-seeing strategy of attacking the human family through the water courses and sources which supply mankind with drinking water, you gentlemen would confer a most inestimable and lasting blessing, not only on the people of this misled and long-suffering community, but upon the whole human race for which, no doubt, you gentlemen, will be substantially and liberally rewarded and the people will ever entertain the deepest gratitude and highest appreciation of your unselfish philanthropy and devotion to the cause of humanity.

Nevertheless it is an unfortunate fact that Mr. Edwin F. Smith has of late years been spending much of his gold-coated time in San-Francisco, Los Angeles and Oakland, cities which are supplied with lake and well water, both of which are of very indifferent and doubtful quality and are strongly suspected by many practical people to be very unwholesome and dangerous waters; and no doubt when Mr. Smith opened his capacious, healthy Sacramento-river-water valves for an intake of those bug-infected waters he became the innocent but susceptible and helpless receptacle of those deliberating, debilitating rogues that the doctors, in their mature wisdom, dominate these cunning, vicious villains to be. The above may not be the real reason of Mr. Smith's attack of typhoid fever, as it is whispered around town here that Mr. Smith holds membership in several high-living clubs, and that it is many years since he drank any water at all, and if he should have the misfortune to return to the use of it again that it would be such a suprise to his stomach that there would be a very respectable and, no doubt, largely attended funeral in about three days thereafter, and our popular Coroner would smile his blandest and most inimitable smile. I myself drink one to twenty-five glasses of Sacramento river water every day, and I am about as clean-blooded and free from fever and all other diseases as most men of my age in this community, notwithstanding the learned opinion and contrary advice of a few all-wise local anti-river-water doctors, their mercenary newspaper supporters and allies and other misguided disciples of those microbe-chasing water experts. I drink this water pure and fresh from the hydrant, without either filtering or boiling, not only to slake my thirst, but because it is a sure preventive and safeguard against all fevers, notwithstanding the adverse opinion of some so-called legalized medical authorities and their mercenary and misled allies. I have known one of the most promising young men of this city who died of typhoid fever in the beginning of July, and who had not drank any other than filtered, boiled and condensed water for six months previous to his fatal attack of typhoid fever; and his surviving relatives, who are wealthy, influential people, are willing and ready to testify to this fact in behalf of the people of this city, who are being fatally misled by a set of thoughtless incompetents. And I can cite a dozen similar cases, any one of which should convince any ordinarily intelligent people of the ignorance and incompetency of the professional fakirs, who have condemned and denounced the use of Sacramento river water, without trial or proper investigation, and contrary to all precedents and the practical experience of nearly all water experts of ancient and modern times.

There is another glaring fact by which I can prove the falsity of the statements made by all of said overweening fakirs: The City Physician and his deputy, whose practice is almost wholly among the poor, who do not boil the water, neither do they filter it or buy well water, and, fortunately, for themselves, they cannot afford to employ the sevices of the regulation plug-hatted and kid-gloved medical sages of this scheme-ridden city, and the results are there was not a case of typhoid fever came to the notice of these two most experienced physicians in their extensive practice among the people of this city during this so-called epidemic of that dread disease. There are many other facts in connection with this medical and newspaper campaign against the wholesome water supply of this city. Marysville is supplied with artificial well water, and there were more cases of typhoid fever there this Spring than there were here, and they are afflicted all the time with ague, malaria and all sorts of low fevers. Lodi, Galt, Ione, Wooodland, Winters, Madison and Chico—which latter is supplied with apparently clear water from a clear lake in Antelope Valley—have been afflicted with 300 per cent. more cases of typhoid fever this year—and all the time—than we have in this city. Red Bluff, Redding, Dunsmuir, Wheatland, Lincoln, Rocklin, Newcastle, Grass Valley, Nevada City and Truckee, where they are supposed to have as good water as the world can afford, and numerous other cities, towns and villages which, to their misfortune, were out of reach of the health-preserving water of the Sacramento river, suffered from a thousand per cent. more cases of typhoid fever than have the people of this city, whose health has been preserved; and the spread of the terrible typhoid fever epidemic which swept over this whole country last Spring has been prevented more effectually by the free and liberal use of the pure and wholesome water of the Sacramento river than any other remedy or preventive that could be employed for the certain accomplishment of that most earnestly desired end.

TYPHOID NOT DUE TO RIVER WATER.

Notwithstanding the unsought, free and water pirates inspired advice of the bloated newspaper windbags and a few of Sacramento's misled and misleading medicos to the contrary, I have a letter before me from the Secretary of the Health Commissioners of Portland, Oregon, in which he says that the decrease in the number of typhoid fever cases in that city, since they substituted lake water for Willamette river water for drinking and all domestic purposes has been phenomenal. Nevertheless and contrary to that statement, I quote here from a printed, tabulated report of the Health Commissioners of that city, the following: "The mortality in typhoid fever continues about the same, there being 22 deaths during 1897, as compared with 25 during 1896."

While there is no doubt the death rate has been reduced considerably it may not be wholly accredited to the change from one quality of drinking water to another. And the fact remains that the number of typhoid fever cases have not decreased very appreciably. I have been talking with a late arrival from that city, a very intelligent, trustworthy and most reliable gentleman, who informs me that the ravages of typhoid fever in that city this year of 1898 is something terrible to contemplate, and likely the Health Commissioners of that city will be called upon to record the largest death rate from that dread disease they or their predecessors have been called upon to chronicle since the incorporation of Portland as a city.

The public must not be misled or carried away with the false impression that that city is supplied with lake water wholly. Bull Run river, it is true, takes its source from a lake of the same name, located in the Cascade mountains, a brief description of which is given here, as taken from the rules adopted by the water Committee of the city of Portland, regulating the public water supply, and the rate charged the inhabitants of that city therefor, together with a chemical analysis of said water:

THE WATER.

The main source of the water supply of Portland is Bull Run lake, situated in the Cascade mountains, at an elevation of 3,500 feet above the level of the sea. The lake, about three miles long, nearly a mile wide and very deep, is seven miles northwest from the summit of Mount Hood. The deep canyon of the Sandy river prevents the discolored waters from the glaciers of that mountain from running into the lake. It is supplied entirely from unfailing springs in the steep, rocky slopes surrounding it on all sides, fed by water from melting snow and rain.

The only outlet from the lake is under an immense mass of shattered basalt, which fills the canyon at its northwest end. From the base of this natural dam, 350 feet below the surface of the lake, the water gushes forth and forms Bull Run river, a tributary of the Sandy, which empties into the Columbia at Troutdale.

Bull Run river, after flowing very rapidly through a rocky canyon nearly twenty miles, is tapped by a pipe forty-two inches in diameter, at a point thirty miles east from Portland, and 720 feet above low tide in the Willamette river, and a portion of the water, without being stored in any reservoir, flows through the thirty miles of the pipe directly into the distributing mains in the city, at the rate of 24,000,000 gallons daily.

TOTAL FIXED INGREDIENTS.

2.7 parts in 100,000 parts by weight, or 1.89 grains per imperial gallon (of ten pounds avoirdupois), consisting of—

	Parts in 100,000	Grains per gal.
Silica	.56	.392
Oxides of iron and aluminum	.08	.056
Calcium carbonate	.39	.283
Magnesium carbonate	.27	.189
Chlorides, sulphates and carbonates of alkali	.40	.280
Organic matter	1.00	.700
Totals	2.70	1.890

And you will observe by comparison with chemical analysis of Sacramento river water that notwithstanding all that has been said and written in praise of the water of Bull Run river, and against the pure and wholesome water of the Sacramento river, it has sustained its old reputation, not only in proving itself to be fully the equal of the much-lauded water of Bull Run lake and river, but has developed a much higher, purer and far superior quality of water than any water with which it has thus far been compared.

The water supply of Portland, like that of our own city, is purified by motion, sun and air, which can only be obtained by the river process of purification and which was the original design of our Creator for preparing drinking water for the use and benefit of mankind and in sustaining all animal creation; and it is the one and only process which separates from water the poisonous minerals of the bowels of the earth by precipitation, and the filthy contagion of the mountain stock ranges, the wild animals of the deep and almost inaccessible ravines and the filthy cow pastures of the high mountains and hillsides, as also from the poisons from the shedded hides of rattlesnakes and other poisonous reptiles, whose venomous poisons are ever polluting the waters of lakes, wells and all still waters.

I observe by the Health Commissioners' printed report of the city of Portland to its Mayor and Common Council that it extols the excellent qualities of its new water supply most lavishly, which, by the way, is done by nearly every board of health in the world—save and except only the ill-fated city of Sacramento. It matters not how indifferent or inferior the quality or quantity of the water supplied in all cities, their boards of health, newspapers, uninformed doctors and public men speak well of it and give it a good name, except in this unfortunate city, where for wholsomeness of quality and abundant and never-failing supply of unsurpassed water we are second to no city in the world, notwithstanding all that is said in praise of Portland's new water supply.

The report says: "And only upon a probable and approximate estimate population of that city at 89,000 that the death rate is only 6.35." The chances are when the census of 1900 is taken they will discover quite a decrease in the number of their inhabitants since the last census was taken, judging from the number of people now residing here who were former residents of that city and who are part of the great exodus from there during the panic years—1892 and 1893 and 1894—caused by the avariciousness and insatiable greed of the gold-cornering combine in those years of dire distress. It is to be hoped, however, that the decrease in sickness and the death rate in progressive Portland will justify the enormous expense the people of that city have undertaken in changing their water supply from the Willamette river to Bull Run River, which change has cost the good people of that city the immense sum of $3,836.508.00. But in view of the unfortunate fact that Oregon is in the hands of the gold-bugs and bond-sharps, whose financial policy is so well guarded by powerful legal defenses that they always possess a large surplus of easily earned gold, with which no doubt, as a means of influencing public opinion their way, they conduct several influential daily newspapers whose editors and other employes of the money power, discovered some very dangerous, determined and destructive disease germs in the water of the Willamette river, by way of preparing a golden opportunity for the bond sharks and a most propitious outlet for their hoarded gold, and that they might thus be enabled to levy and collect usurious tribute from the good people of that bond-ridden city for many years to come.

In comparing the death rate in many cities of the United States, I find that Omaha, Nebraska, which takes its water supply from the Missouri river, with an actual population of nearly double that of the estimated population of the city of Portland and not having near as mild or favorable a climate has a lower death rate than the latter city with its estimated population of 89,000. The death rate per thousand for Portland is 6.35. Actual population of Omaha, Nebraska, 140,000. Death rate per thousand in that city, 6.187. Certainly, the Sacramento river is no more subject to nor susceptible of contamination or pollution from Pitt river, its source, than is the Missouri river from Fort Benton to Omaha. I will cite here for the benefit of the anti-Sacramento river maniacs, a most convincing proof of the absolute purity of Sacramento river water over all other waters supplying any city on the Pacific Coast or anywhere else.

A SQUARE TEST.

There is a gentleman of my acquaintance in this city who has Sacramento river water put up in a vessel now nearly two years, and it is to-day as clear as crystal. And I have a pitcher of Sacramento river water in my own possession for over six months, and it is just as clear as is possible for water to become. It never underwent any system of filtration, or artificial purification other than to pour it into another pitcher after the sediment was precipitated from it, and it is now as sweet and agreeable to the taste as the day it was drawn from the hydrant, which proves it to be fully the equal, not only of the waters of the Nile, but the equal of any water in the world. And this, notwithstanding its learned and solemn condemnation without test, trial or any form of analysis, knowledge or information whatever, by a certain set of incompetent, avaricious medicasters and the newspaper lackies of the greedy water combine conspirators, from whom all this anti-river water inspiration and lying is emanating. For comparison, experiment, example and instructive information let any interested citizen who entertains a shadow of doubt as to the superior quality of Sacramento river water over any well water ever discovered in this county, take a pitcher of any well water now in use, or recommended by your learned doctors and their newspaper allies and other pseudo scientific bacteriological experts for drinking and all other domestic purposes for the oft-misled people of this buncoed city. And if said well water is not as green in less than two weeks as the grass, or the foliage on the trees in the vicinity of the location of said wells, then I will admit that I am wrong. And in addition to this, strong evidence of the presence of organic matter, fungi and decaying vegetation, poisonous acids, alkali and other mineral poisons will be found. It becomes ropy with a white, slimy and most disgusting substance which would justify the owners of those wells instead of wasting their energy, time and money in booming their disease-breeding and death-dealing water, and forcing it upon the ever credulous and gullible people of this scientific and professional fakir ridden city to just establish a gigantic rope walk and a half dozen of soap and candle factories, and by letting the water of these wells stand a few days it will supply all the necessary material to make a brilliant success of all three of those profitable industries.

In further proof of the danger of drinking well water, we have on the stubs of the City Collector's receipt books, a record of over one hundred and fifty dollars money paid by Mr. Clark, who conducted a pottery for years, East of town, for water which he bought of this city, for the preservation of the health of himself and family, notwithstanding the fact he was the owner and possessor of wells, which contained an inexhaustible supply of sparkling, clear water. I know also, at this present time, a well-to-do resident of Orange Vale who carries Sacramento river water from this city up to that beautiful foothill town. And this same gentleman was once impressed with the firm belief that his well of sparkling, clear, mountain water was the purest, coolest, best and most wholesome water on earth, but after its constant use for a short time he was effectually and finally convinced of the error of his judgment, and very gladly substituted the learnedly and scientifically-condemned Sacramento river water. Verily, the learning and wisdom of a few of the doctors, newspaper men and other sages in this community surpasses all conception of the ordinary mind. And the great wonder of it all is that other commuties are not complaining, many of which contain from one million to five million inhabitants, who are supplied with drinking water from rivers. This density of population, with their manufacturing and commercial interests, are certainly and naturally exposed to a million times more contamination and pollution than the water supply of this city can possibly be exposed to in a thousand years. But those people are not constantly reminded of the many dangers of contamination to which their water supply is ever exposed. It is not to be wondered at that the unfortunate, misguided people of this community, who have been and now are paying for and using the sparkling, pseudo-pure, clear water from the alkaligenious wells of this city and vicinity, which are not only the filthy drainage of the pig pens, hog wallows, cow pastures and all the impregnated contagion of the cesspools of this city and suburbs, but much worse and more dangerous to the health of the people and destructive of human life, because these same wells are the absorbent sink of four cemeteries; where the decaying and putrid corpses of the Jew and the Gentile, the Chinaman and others, have been emitting their poisonous effluvia and commingling it with the waters of these wells nigh on to fifty years, thus adding vicious disease-breeding and death-dealing microbe germs to the so-called sparkling, clear, well water of the City of Sacramento and its suburbs for five miles around, are doing so under an error of judgment, produced in their minds by the false statements and misrepresentations of a greedy gang of scheming, avaricious vipers, who hatched one of the most vicious and outrageous plots to rob and disinherit the people of this municipality of the most vital of all the public utilities, and the last source of revenue they have left them. And this, in order that the top-loftical, wise, know-all, sage-like, silent, supercilious posers, the sneaking, kid-gloved, plug-hatted, professional fakirs, and their newspaper and other, but more ignorant allies and lackies, and other influential gentlemen of our rising parvenuocracy might live in abandoned ease and extravagant, unbridled luxury off the sweat and toil of the disinherited business people, and the common herd of this commuity.

It is very obvious to the most ordinary intelligence that those faking gentlemen who write and talk so much abont the water of the Sacramento river, do not manifest much knowledge of the numerous difficulties attendant upon procuring an abundant supply of wholesome water for municipalities. The absence of any reference to these difficulties by the learned sages, who denounce constantly and unsparingly, the absolutely pure and abundant water supply of this city, is in evidence of their utter ignorance of this most important of all subjects, affecting the interests and health of the people. Therefore, it proves their incompetency to pass judgment upon the quality of Sacramento river water, lake water, driven or artesian-well water, or any other quality of water. The only knowledge they possess on the subject amounts to this: One of these gentlemen makes a charge that certain water is polluted with disease germs, particularly the disease most prevalent at the time he makes such charge; and others of these wise and profoundly-learned water experts and disease germ detectives write an article in support of said charge, which is published in some medical magazine and is only the mere theory or opinion of one or two men unsupported by precedent, practical experience, chemical or bacteriological analysis, or the experiments of the studious, philosophic and philanthropic minds of all ages; but with a self-satisfied air and an overweening, assumed and dignified vanity, they ask each other, and sometimes they actually deign to inquire of some layman if he has read such and such an article, which appeared in a certain medical and scientiffc magazine, bearing him out in his views on the water qusstion. As much as to say, "You see, I am just right in my views on this subject, and in view of this fact I know and believe there is no man nor set of men brazenly bold enough to question my theory, supported as it is by a distinguished medical magazine and all the local newspapers, and many of the good people of this fair city." The latter, however, are nearly all newcomers, who are not familiar with the scientific character of the few, untraveled, uninformed and inexperienced doctors who are opposed to the use of river water for drinking and all domestic purposes. And who, of course, know that the newspapers are not actuated by any sordid or mercenary motive, and that they are merely conducted in the interests of and for the benefit of humanity; and that the proprietors and attaches of said newspapers sleep outdoors in this glorious climate, and live on California's pure, bracing air and sparkling, clear water, from the alkali wells in and around this city. And, therefore, these unwary, misguided people continue using for drinking purposes either boiled river water, or keep on buying this ague, malarial well water, so as to make business for those highly-learned, philanthropic doctors, and to give prestige to the wild and unjust claims of one W. E. Henry, for the enormous sum of $571,000, for breach of contract in connection with the contemplated robbery of the people of this city of their entire water supply in the year of grace, 1893. A part of the infamous scheme is to give emphasis to the claims of those uscrupulous, avaricious hell-hounds who employ the most deceitful means and misleading arguments for the accomplishment of that nefarious plot, of which Mr. W. E. or J. H. Henry were little more than agents for the invisible rogues who hatched that thieving conspiracy. Evidently they are no more now in their suit against the city. However, I cannot other than admire their monumental gall, for endeavoring to force the good people of this city to pay them back the money they expended in their bold attempt to rob them of this most useful and valnable of all the public utilities. I can recall to mind a case tried in one of our courts a few years ago, where an unfortunate man stole $1.75, and was sentenced to eight years in the Folsom prison, not so much for stealing so trifling a sum, but merely for his intentions. But here comes the agent of a crowd of suave, plug-hatted schemers, having failed to rob the people of this city of property averaging something like five millions of dollars, and asks the courts of this State and the United States to force the people of this city to pay them the enormous sum of $571,000 for their thieving intentions. Mr. Henry and his employers really should be elected to Congress.

I again appeal to the people of this outraged community to take immediate but firm steps to suppress the false statements and vicious, misleading charges that have been made and are still made and disseminated broadcast through this State, and in fact, the whole United States and Europe, to the effect that the Sacramento river, which supplies this city with drinking water, is terribly charged with all species of disease germs, and especially that it is running brimful of the vilest of typhoid fever germs, which disease, unfortunately for the oft-misled people of this city, happens to be epidemic, not only over this Pacific Coast, but it is said the terrible scourge is prevalent over the whole of North America. I find upon inquiry that there are numerous cases of some very low fevers prevailing in many and various sections of this State; through Yolo county there were several cases of typhoid fever; through Colusa, Placer, Nevada, and many other foothill and mountain counties; Elk Grove, Galt, Sheldon, Folsom, Oak Park, and many other towns in this county where it is certain the people do not drink Sacramento river water. Even the death roll of San Francisco last spring was higher than it has been for years; it being in May last 18.24 per thousand, which is attributed to the dry season, as it certainly cannot be charged that the Sacramento river water was reponsible for this terrible epidemic of typhoid fever which is raging over the whole country this year, where, unfortunately for the victims of that terrible scourge they cannot have the pure water of the Sacramento River, which is a certain typhoid preventive. The patient people of this city and the world at large, are told in raw head and bloody bones style of glaring headlines by the local newspapers of this city, and even by the San Francisco *Call*, of the polluted, death-dealing water of the Sacramento River. The latter newspaper with its State, national and international circulation and influence instead of lending its support to further advance and give tone and prestige to the midnight-incubated schemes of a combined gang of avaricious water pirates, who have for years been using all manner of subterfuge to own and control the water supply of this city that they might be enabled to exact exorbitant prices from the people for the water which they know they must have at any cost, ought to advocate the emancipation of the people of its own city from the political-corrupting, demoralizing and crushing influence of the Spring Valley water monopoly; first, by strongly and strenuously advocating not only the propriety, but the necessity of municipal ownership of the water supply of the great, rich city of San Francisco, which can at any time be made the victim of a water famine, whenever the exacting demands of said monopoly are not acceded to. In order to assist in the accomplishment of such an inestimable blessing for the suffering tax-payers and householders of that city, I advance an idea here which may prove of incalculable value to the people of San Francisco, not only in freeing them absosntely from the baneful influence of a soulless water monopoly, but in securing for that city an inexhaustible and never-failing supply of the best, swwetest, most wholesome and nutritious water in the world, and for less money than they can possibly obtain such supply by any other method or means. This plan which I suggest is to tap the Sacramento River north of this city and convey the water to San Francisco by great water mains, where it can be distributed to the people, perfectly clear, from settling reservoirs, which can be maintained by the city at a nominal cost. A. W. Von Schmidt in 1870 had partly organized a great water company for the purpose of supplying Marysville, Sacramento, Stockton, Oakland, Alameda and San Francisco with pure mountain water from Lake Tahoe, which was to be conveyed to the North Fork of the American River by tunneling the Sierra Nevadas, and thence to all towns and cities between that place and San Francisco, inclusive. By adopting my suggestion San Francisco can have as good water as the Von Schmidt Company could possibly have delivered to that city and its people can avoid the enormous expense that would necessarily be entailed in tunneling the mountains, and have a municipal water supply that would be the equal of any in the world, both in quality and quantity. Then Mr. *Call* when you get this good work accomplished for your own city, try and assist your next door neighbor, the water monopoly-crushed city of Oakland by making an immediate demand for the improvement of the quality of the water supply of that city, as San Francisco, Berkeley and Oakland, and I might include Los Angeles, have the most indifferent and inferior quality of water of any cities I know of, and they are ever at the mercy of unscrupulous water combines who can always have rates fixed to suit their avoriciousness and by which they can exact extortive prices from the people of those cities.

No doubt the water from Chrystal Springs furnished San Francisco is very good water, could it be delivered to the people by water mains directly, instead as it now is from storage reservoirs with natural bottoms, where grass, fungi and all sorts of vegetable matter is propagated. In proof of this fact, in the course of my investigations of the drinking-water question, I visited the inlet of two of the receiving and distributing reservoirs of the Spring Valley Water Co. in San Francisco. The surroundings seemed to be cleanly and very well kept. The reservoirs have very good substantial beds and sides. The University reservoir is prepared with asphaltum rolled solidly on felt. And I observed at the same reservoir a system of filtration which, while simple and inexpensive, made it plainly obvious that there was considerable vegetable and other objectionable material conveyed in the mains from Chrystal Springs and Alameda Creek to those distributing reservoirs, which is impossible in river water. Those filterers consist of a series of screen frames, covered with cheese cloth and placed in slots, through which the water passes from the supply mains to the reservoir, and by this simple process the heavy tree branches, fungi and other decaying vegetable matter is withheld and separated from San Francisco drinking water. I visited the reservoir at West avenue and Elsie street, which is the receiving and distributing reservoir of water from San Andreas Lake. The Spring Valley Water Company there maintains an aermotor where the water is lifted up some twelve feet high and passed over and into a receptacle some twelve to sixteen feet long and shaped something like a watering trough, divided into two compartments by a partition which stands about twenty inches above the outer edges of said receptacle, which are slightly curved outward on the top edges. By this make-shift and costly method San Francisco's drinking water is being constantly agitated and exposed to the sun and air for the purpose of of purifying it by nature's own process and eliminating from it thereby the ammonia, arsenic, sulphuric acid and other poisons, and the alkali, antimony and the various and numerous impurities that all well, surface and lake waters are subject to and impregnated with. This artificial process of purifying drinking water is only a mere parody on, and a very feeble attempt to, imitate the great and inimitable work of the Almighty God, whose purifying process is going on perpetually in rivers and all running waters. This artificial process is made absolutely necessary by physical conditions and the great difficulties confronting the good people of San Francisco and the Spring Valley Water Company to find a sufficient supply of wholesome water within easy distance of that city, and at a reasonable cost to the Company and people of that place. Every city receiving its water supply from surface lakes and wells has to encounter and expend large sums of money to overcome these most stubborn difficulties. Boston, which is supplied with Cochituate Lake water, has spent millions of dollars in endeavoring to maintain its purity and fitness for the use of the large number of inhabitants of that city. Lynn, in the same State, and only a few miles distant from Boston, has to encounter and overcome these same difficulties at great expense to the people.

If any man is anxious to satisfy himself as to the correctness of these statements in relation to lake and surface water he needs only to visit the Contra Costa Water Company's filtering plant near San Lorenzo. He can see hundreds of casks of alum rolled in there daily to be used in clarifying the water of Lake Chabot. But as they maintain two systems of filtering by the first makeshift and primitive system can be seen the green, slimy, decaying vegetable matter, and the starchy, filthy-looking fungi withheld by the wire screen-cheese-cloth system of filtering, which is enough to disgust any human being living with lake water for drinking purposes, or even bathing in it. Any man of ordinary common sense or practical experience can easily understand that lakes, wells and all still or immovable waters are peculiarly favorable to and well adapted for the generation and propagation of all species of animalcule, microbes and disease germs of every hue, notwithstanding the bright and pseudo, logical, bacteriological opinion of a few members of the Board of Health of this city, and two or three medicasters and water combine, mercenary newspaper hirelings to the contrary. Yes, Messrs. medical and mercenary newspaper drinking water experts, all lakes and wells are susceptible of pollution, for the reason that they are the natural drain of privies, sewers, cattle and stock ranges, decaying vegetation and nearly all the filth of the surface of the earth without possessing any natural facilities or power of purification such as all rivers possess according to the inimitable plan of our Creator, which has been clearly demonstrated upon a thousand occasions from time immemorial. It has been given as the unbiased opinion and the result of all scientific research that river water was always the purest, safest and best drinking water for the general use of towns and cities. In the face of all this convincing evidence and the irrefutable fact that 99.75 per cent. of all the cities of the earth are built on the banks of rivers, and their inhabitants drink the waters of rivers without complaint or fault-finding, the good people of this city are led to believe that they are the only people on earth supplied with river water. But, say the mercenary water combine pirates, inspired newspaper lackies and a few medical charlatans, their allies, the waters of deep driven, cased wells, are completely filtered by passing through certain strata of clay, which claim is correct so far as the clearing of the water and appearance of it to the eye, or even the disagreeable odors are concerned. Nevertheless, the incontrovertible fact remains by careful investigation, chemical, bacteriological analysis it has been proven beyond the possibility of a doubt that while the appearance of the filthy, decaying and disgusting matter from which such water is derived and through which it passes before it commingles its contaminating influence with the subterranean water and subterranean rivers about which we hear and read so much nowadays, that it carries much of the filthy contagion of the surface of the earth with it, thereby polluting the subterranean water of all thickly populated places. No doubt remains in the minds of all scientists whose attention has been called to investigate that subject.

Now, fellow-citizens, in view of this most unjust campaign of falsehood and misleading misrepresentation, I again appeal to you to take immediate steps to suppress and counteract the retrogressive, obstructive and property-depreciating influence of less than a dozen of the fifty doctors with which this hapless town is afflicted, and the influential and social "push" of the anti-river army, who apparently have only one object in view—that is, to transfer the ownership of the water supply from the people, without compensation, to a private corporation. And with that object in view, these profoundly-learned, microbe-bacilli, disease-germ chasers and ever-accurate locators—to be sure—these great secientific experts never fail to find those voracious hordes of horrible, demoralizing, debilitating, health and life-destroying, ever-hungry, gluttonous microbes in the water of the Sacramento. The fact of their presence, and that of their numerous families in the water supply of this city, is drummed and has been drummed Into the susceptible ears of the deceived, credulous and easily misled people of this city for the past five years. These cunning schemes are always hatched by those whose virtues are greatly exaggerated and freely eulogized. Abilities which they do not possess are very liberally advertised as our great "statesman" and "leading citizens," who manage by some hook, crook or triangle to lead themselves to good, fat jobs at the public, profitable place dispensary, and then they throw their official influence in the conspirators' scales, to enable them to consummate their avaricious, demoralizing and impoverishing plots upon the confiding, unsuspicious people off whom they live.

The stay-at-home warriors, Generals, Judges and alleged civil engineers, fighting newspaper men, a list of whom I have now before me, with their names affixed to a petition, are requesting the very liberal Supervisors (with the taxpayers' money) to substitute alkali and other poisonous well water in the County Court House and all county offices, including the public schools of this city, the latter at a cost to the dear people of $5 per day, for pure, wholesome river water, which contributes to preserve the health of those children more than any other factor in their existence. Nevertheless, the petition was immediately complied with, and the aforesaid great sages, political economists and statesmen gave their duped constituents another convincing proof of their wisdom in substituting a water in the public schools of the city inferior in every particular to that furnished by said city, and for which the parents of those children are paying the price demanded by said city, and with which they are well satisfied. This filthy substitute costs these same overtaxed parents $5 per day for an average day of five hours for five days of the school week, or twenty-five hours out of a hundred and sixty-eight hours. What extraordinary economy and wisdom manifests itself here in these hard times to a people who are already overburdened with taxation. But evidently it was not their interests those liberal statesmen were considering. Their object seems to have been to give tone, prestige and official sanction to the deep laid scheme of the water brigands, and against the best interests of their own constituents who are paying them liberally for the little time they devote to the interests of said deceived constituents.

DITCH WATER COMPARED WITH RIVER WATER.

Here is a fact that should be known to all the taxpayers residing in this conspiracy-ridden and plot-threatened city, that there is a shrewd scheme already prepared to substitute the fatal fever, ague, remittent and intermittent and death-dealing water of a certain ditch water company's water, under the popular disguise "clear water." Notwithstanding the clearness of this reputed pure, spring water, it has carried disease and death in its wake in the fairest part of the foothill counties through which it passes, and has become notorious as the breeding and abiding place of the most virulent fever and ague known to any part of this State, or the United States. This, anterior to the advent of that fatal water, was recognized by health-seekers as the greatest health-recuperating locality in the world. Nor is it surprising that this ditch water carries disease and death in its course, as its storage reservoirs have only soil or natural bottoms, from which in many instances, great trees have been hewn, the stumps of which remain, together with mountain fern, poison oak, all species of poisonous weeds and other decaying vegetable matter, which is most favorable to the speedy generation and propagation of big, fat, vigorous disease germs, and being of a wild, mountain cowboy disposition, leaves no doubt they would annihilate all the people and depopulate the whole of northeastern and central California. There are many other features about this ditch water for which it should be condemned as drinking water by all people of ordinary intelligence.

There are many sawmills operated upon the banks of this ditch which are supplied with power by said ditch water, which is carried by wooden flumes in many places, some of which are over twelve hundred feet long, and from which the imprisoned, monopolized water absorbs various deadly poisons. Most of this water is not mountain spring, but snow water, and it is a well known fact that this virgin snow water is not the pure water that people, not well versed on the subject, think it is or believe it to be. The snow comes down very often in a close, compact body like a sheet in mountain regions where charcoal burning is going on all the time and locomotives are passing continuously, the smoke and gases arising from which generate arsenic, sulphuric and other poisonous acids together with microbes, with which the air like everything else is surcharged, and they come down frozen dead into what is presumed to be pure water. Instead of being destroyed and eaten up by other microbes, thus purifying the water, a process of purification which is ever going on in rivers, they commingle their putrid carcasses with other poisons in this apparently pure snow water until various fatal diseases are carried into the homes of unsuspicious people.

In a conversation with an eminent physician recently, and by the way, I must say for him he is the most intelligent doctor with whom I have had the pleasure of talking on the water question for some time—he informs me that in the city of Deadwood, which is one of the highest cities in the United States, and which is supplied altogether with snow water, that when men first become residents of that place they seem to become very strong and vigorous, which they ascribe to the high altitude and the pure air thereof, but which, he says, results from the supreme efforts of over-taxed nature to rid itself of arsenic and other poisons taken into their susceptible bodies by polluted snow water. Instead of recovery from its evil effects, premature and certain death is generally the result, so that there is no city of its age in the world where the cemeteries have grown so rapidly.

Had this same snow water gone through the rough river process of purification by motion, sun and air, precipitation and evaporation would have purified it and made it fit for the gods.

Here is another instance of a water which has been lauded up to the skies by a few medicasters and uninformed newspaper water experts of this city. That is the famous virgin snow water of Blue Canyon. Certain trainmen, whose run is over the Sierra Nevada mountains, had been using this medicaster and newspaper highly recomended water, and whole train crews were down with fever, ague and other sickness two-thirds of their time until friends of theirs, who didn't happen to be Sacramento doctors, advised them to substitute Sacramento River water for the much-praised and freely advertised virgin snow water of Blue Canyon. The train men took their friends' advice, and lo, and behold, the change in their physical condition was almost miraculous and immediate. The Sacramento River water is now being carried over the mountains by many train crews who suffered untold miseries from the constant use of the much-lauded virgin snow water from the deep ravines of the Sierra Nevada mountains, of which I am prepared to give many other instances, notwithstanding the high authority and earnest recommendations of the few wise anti-river water doctors and newspaper hygienists to use Blue Canyon water for drinking purposes by all means—a recommendation that is merely a prelude to transferring the ownership or part ownership of the water supply of this city over to a private water combine under the deceptive, misleading guise of pure mountain spring and virgin snow water, to be delivered east of the city for a stipulated amount of money per million gallons, water meter measurement. That, of course, will necessitate the municipality to adopt the same system of dealing out the water to its people. This is the fixed and firm intention of the combine water pirates.

The representative of a certain ditch water company made a proposition to myself some two or three years ago, and I have heard it from many other sources and leading citizens, and the "Daily Morning Water Pirates' Phonograph" has taken upon itself the responsibility of advising the city officials when they put in their geeat new water main to lay it so that the water supply could be received at the east of town, and this seems to be the sordid motive underlying the vicious newspaper campaign of falsehood and misrepresentation which has been vigorously prosecuted against the wholesome drinking water supply of this city. A few narrow-minded, uninformed doctors and their ignorant disciples for five years last passed have by misrepresentation enlisted the far-reaching influence of the San Francisco Daily *Call* in support of their nefarious plot. If that paper would busy itself on the subject of pure water in its own city its employes would not have to travel ninety odd miles to find work on that subject in plenty.

OFFENSIVE SAN FRANCISCO WATER.

On my recent visit of investigation of the condition of the water supply of the City of San Francisco, I visited the Secretary of the Board of Health of that city and inquired what was the cause of the drinking water of that city smelling so disgustingly loud several months every year. I was informed there that that offensively stinking smell was caused by the presence in the water supply of a little bug that was quite harmless, and I was assured by the deputies in the office of the Board of Health that its intentions were not bad, nor of an aggressive, homicidal character, and that this vast army of bugs were not themselves responsible for their villainously bad breath. Nevertheless, they leave a very bad impression on the minds of the unfortunates, who, of necessity, have to take them into their stomachs, and lead one to believe that they must have had their origin in the putrid remains of a skunk. The existence of such a tribe of foul-smelling wretches, thank God for his goodness, is impossible in rivers, and particularly is it impossible for them to exist in the pure and wholesome water of the Sacramento River, which, like the waters of the Nile, are always good and palatable. Hence, I would suggest to the *Call* to occupy its spare time in fishing for and capturing those villianous bugs, or water-skunks, which make the drinking water of their own city so disgustingly vile several months of the year, and by ridding the drinking waters of their own city of the presence of those minute vile water polecats they would be rendering a much greater service to humanity than by lending their influence to furthering health destroying and demoralizing midnight schemes of a set of villainous water pirates in this bond and other conspiracy ridden city, whose pure and wholesome water supply has been condemned without the support of knowledge, experience, or scientific authority, and contrary to all the chemical and bacteriological analyses, and the practical experiments which have been made of the drinking water of this city for nigh on to fifty years. Each and every test of this water has proved conclusively that the water of the Sacramento River is the *creme de la creme* of drinking water, and stands the same test today, and proves its envious title to first place among the drinking waters of the world, notwithstanding its condemnation without trial, by a set of ignorant, professional fakirs, and water corporation inspired blatherskites, until they have produced conditions of doubt, despair and timidity in this otherwise fair and healthful city, which is most pitiable and lamentable to contemplate. They have frightened away visitors and intended visitors and capitalists, who desire to settle in our midst, and take advantage of our salubrious climate, fertile soil, the abundance, rarity and variety of our tropical fruit, our flower adorned lawns and gardens, and the sweet aroma of our magnolia and orange blossoms; the unsurpassed, balmy, bracing breezes of the south; our cloudless skies, calm and beautiful evenings; and our unrivalled advantages and business prospects of our location as a base of supply and distributing center. And even young men and women of this city, who are attending the State University, wrote their parents that they were afraid to spend their vacation home on account of reading so much in the newspapers about the Sacramento river water which supplies the city, being surcharged with typhoid fever and all species of disease germs.

Those falshoods and lying statements are being most assiduously disseminated broadcast, not only over the entire Pacific Coast, but the whole United States and Europe, until this city has become the laughing stock and a by-word for the whole country and a place to be avoided as a pest or a charnal house.

And water companies have sprung up like mushrooms in a night, and are now organized all over the city with such signs and advertisements as these: "Sacramento Pure Water Co.," "Anti-Malaria Water Co.," "Anti-Typhoid, Artesian Well Water Co." Circulars of the above type are being distributed all over this would-be water thieves enslaved city.

The water of those new companies is being delivered to the misled people of this community, from holes bored adjacent to the stables of some gentlemen interested in some of these water companies, and in other back yards of the city, and from the drainage of hog pens, stock ranges and cow pastures of the neighboring ranchers, until demoralizing conditions have obtained here for which no parallel can be found from East Cape to San Francisco.

Under existing circumstances, and in view, of the fact that the people of this city have spent considerable money in trying to boom it in the past, and have had a souvenir printed and distributed describing the many advantages of our city and its surroundings, and have liberally contributed to the maintenance of an exhibition of the products of California, on wheels, to induce and encourage emigration of good people to this section of the State, and also maintained a factory promoter at a liberal salary for a long time. All of which energy and money seems to have been expended in vain, and rendered nugatory by the all-wise and deeply-learned declaimers against the pure wholesome water supply of this city. In view of all these facts, and the obstructive and retrogressive conditions produced in this apparently-doomed community by inexperienced, lying and incompetent water experts, it would seem to be the plain duty of the people of this city whose business and property interests are involved, to hold public meetings for the express purpose of denouncing in unmeasured terms, by speech, resolution and practical demonstration, that you are determined at all hazards to suppress and counteract the evil influence of those uninformed, misleading, self-elected water experts, whose misrepresentations are continually giving your fair city a black eye and a bad name, and are retarding its growth and progress by condemning the pure water supply of your city without trial or test of any character whatever. When this denunciation of the city's water supply was at its very highest, the scholarly Dr. De Arcy Powers made a bacteriological analysis of the Sacramento River water, which he found to be absolutely free from typhoid and all disease germs, and he pronounced it good, wholesome water, as has every chemist and bacteriologist who has made these tests in the past fifty years. About the same time my intelligent friend, John Robertson of Cotati, sent in a communication to the *Evening Bee* describing a typhoid epidemic which raged in the densely populated city of London, 35 years ago, a city which is supplied with drinking water from the rivers Leigh and Thames. But before the Board of Health or the newspapers of that populous city condemned the waters of those rivers, they held their patience and withheld their opinion until they made a thorough investigation of the cause of the epidemic, and as a natural and usual result, the cause was discovered to have originated from a well which supplied water to wash the milk vessels of a dairy which furnished milk to that particular section of the great city. This dairy was eighty miles distant from the scene of the terrible infection of the city. The result of the careful investigation of the foregoing cause of an epidemic in a populous city, is identical with all the investigations, natural and scientific tests and the practical experience of all animalculists, water and hygienic experts since the world commenced, that typhoid and other disease germs have been found almost exclusively in well water. Notwithstanding the advice of certain members of the Board of Health of this city to seal up all the hydrants supplying good, pure and wholesome water to the public schools, Sacramento River water has been the great conservator of the health of this city, since the people have had the good fortune to establish their municipal water plant, and take their abundant supply of wholesome water from the Sacramento River, and refuse to substitute therefor water from the alkali, ammonia, arsenic, sulphuric acid, and other poisonous acid wells of this city and its suburbs, at considerable expense to the taxpayers and parents of those children, whose health and lives are exposed to all those epidemics which result from drinking unwholesome water; but this advice is in line with the doctors who compel little tots of children, attending the kindergarten schools, to pack bottles of boiled water with them to school, the use of which can only result in producing a generation of soft-boned, tissueless imbeciles, who will be an incumbrance on their parents and friends, and a final charge on the public.

Until several of Sacramento's medical and newspaper microbe experts die off, or until the State adopts measures to cure them of this terrible new disease, which from the deplorable mental, physical and moral condition to which it has brought them, should be called microbe-mania; the immediate attention of the State Board of Health should be called to diagnose their case.

In conclusion, I desire to call the attention of this gullible public to an instance of how they are being constantly misled by the brazen cheek and unblushing gall of certain members of the Board of Health of this city, learnedly wise members of which appeared before the City Trustees at their regular meeting of the 8th of August. One of these so-called water experts declared boldly to that body, and in the presence of a thronged gallery, that he held in his possession a letter from the Mayor of Atlanta, Georgia, informing him that all river water supplying that city had been condemned, and artesian and driven well water substituted therefor.

In view of the fact that I have received a letter from that honorable gentleman of the date of June 24th, this year, wherein the very opposite information is given and which is published elsewhere in this article verbatim, it will give the people of this outraged community an idea of the depths of lying depravity this avericious army of anti-river charlatans can stoop to and the false and vicious means they employ to accomplish their nefarious ends.

I am, most respectfully,

JAMES H. DEVINE,
724 K Street, Sacramento, Cal.

Augnst 10, 1898.

REPORT

OF THE

Citizens' Water Investigation Committee

OF THE

CITY OF SACRAMENTO.

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Citizens' Water Committee.

L. TOZER, Chairman.

H. H. GRAU, Vice-Chairman.

S. LUKE HOWE, Secretary.

Arnold, J. H.
Briggs, Dr. W. A.
Drescher, P. C.
Fox, Thomas.
Grau, H. H.
Hall, T. B.
Hassett, W. J.
Henderson, Dr. A. M.
Ing, J. C. Jr.
Lindley, D. A.
McKay, D.
Meister, A.
Scott, Tom
Smith, F. E.
Stillman, Howard
Tozer, L.

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Report of Citizens' Water Committee.

To the Honorable Mayor and Members of the Board of Trustees of the City of Sacramento—Gentlemen: On the 3d day of July, 1899, His Honor, Mayor Land, upon the recommendation of the Board of Trustees, appointed the following named citizens as a committee on investigation in the matter of a clear water supply for the city of Sacramento, to wit: L. Tozer, Herman H. Grau, T. B. Hall, J. H. Arnold, F. E. Smith, Thomas Fox, F. B. Adams, Howard Stillman, D. McKay, R. I. Bentley, Stephen Uren, P. C. Drescher, D. A. Lindley and Drs. A M. Henderson and D'Arcy Power.

Mr. Stephen Uren declined to serve and Mr. Thomas Scott was appointed in his stead.

On July 26, 1899, Mr. R. I. Bentley tendered his resignation because of his inability to give the time necessary to properly investigate matters before the committee, and Mr. A. Meister was appointed by the Mayor to fill the vacancy.

On September 20, 1899, Mr. F. B. Adams tendered his resignation as a member of the committee, and on October 4th Mr. W. J. Hassett was appointed by the Mayor to fill the vacancy.

On the 26th day of March, 1900, Dr. D'Arcy Power, owing to removal from the city, resigned as a member of the committee, and Mayor Clark appointed Dr. W. A. Briggs in his stead, April 21, 1900.

Mayor Clark also appointed J. C. Ing, Jr., President of the Board of Trustees, a member of the committee.

ORGANIZATION.

The original committee was called together by His Honor Mayor Land on the 8th day of July, 1899, at the office of the Mayor, who stated that the object for which the Committee was appointed was to fully investigate the several water propositions then under consideration, to the end that a report should be made to the Mayor and Board of Trustees, recommending the best and most economical plan by which an adequate supply of clear, pure water could be secured for the city. Thereupon the committee organized by the election of Lewellyn Tozer, Chairman; Herman H. Grau, Vice-Chairman, and S. Luke Howe, Secretary.

OBJECT.

The following subdivisions are an outline of what the committee conceived its duty to be, to wit:

1. To investigate and determine the character and condition of the present water supply of the city of Sacramento.

2. To ascertain the effect of filtration and the advisability of establishing a filtration plant for the city of Sacramento.

3. To present an estimate of the cost of establishing and maintaining the same.

4. To investigate the supply of water from the East Side Wells as to quality, quantity and cost of obtaining and maintaining such a source of supply for the city of Sacramento.

5. To investigate the feasibility and advisability of obtaining a supply from the American River, or its tributaries, its character, quantity and probable cost of obtaining and maintaining the same.

6. To investigate the feasibility and advisability of seeking other sources of supply.

7. To report its findings and recommendations, together with such evidence as may be useful for the guidance of the Honorable Board of Trustees of the city of Sacramento, in acting prudently and for the best interests of the city in the matter.

MODE OF OPERATION.

To facilitate its work, the committee at once decided to form sub-committees to which certain phases of the questions proposed to it for consideration were assigned, the Chairman appointing them as follows:

ON WATER ANALYSES.

D'Arcy Power (Chairman), A. M. Henderson, Howard Stillman.

ENGINEERING FACILITIES.

American River—J. H. Arnold (Chairman), P C. Drescher, Thomas Fox, Herman Grau, F. E. Smith.

Sacramento River—T. B. Hall (Chairman), F. B. Adams (resigned), W. J. Hassett (appointed), Thomas Scott.

East Side Wells—A. Meister (Chairman), D. McKay, D. A. Lindley.

Later on two other sub-committees were formed, as follows:

MOUNTAIN SUPPLY.

D. A. Lindley (Chairman), T. B. Hall, Howard Stillman.

SUPPLY FROM JUNCTION OF SACRAMENTO AND AMERICAN RIVERS.

P. C. Drescher (Chairman), D. A. Lindley, T. B. Hall, Herman H. Grau, J. H. Arnold.

Early in its deliberations the committee felt the need of an expert engineer to give direction to its work, and an assistant to conduct active operations, but as such an organization would have involved considerable expense it was deemed best that the general and subcommittees first gather the required information and data so that the work of an expert would be reduced to a minimum. It was also thought advisable to become better informed concerning water systems elsewhere, and to confer with engineers of established reputation whose services might be required as the work progressed. Accordingly Chairman Tozer, while in the East, was requested by the General Committee to visit filtering plants in Eastern cities, also to confer with one or more water supply engineers in relation to their coming to Sacramento. He accordingly did visit and investigate the water systems of the following cities and towns, to wit:

Richmond, Va.; Norfolk, Va.; Long Branch, N. J.; Mt. Vernon, N. Y.; Lowell, Mass., and Louisville, Ky., and conferred with engineers Allan Hazen, G. W. Fuller, C. R. Hermany and others. The information thus gained was duly reported to the committee, and by the courtesy of engineers Hazen, Fuller and Hering various published reports of Water Commissions elsewhere were placed in the hands of the members of the committee for their information and guidance.

Vice-Chairman Grau, by request, also visited the filter works at Kansas City, Kan., and Kansas City, Mo., and duly reported to the General Committee the result of his observations.

In September, 1899, Mr. H. Schussler, Chief Engineer of the Spring Valley Water Works, San Francisco, visited Sacramento upon the invitation of the General Committee and after examination of the proposed plans Mr. Schussler furnished the committee with much valuable information concerning a public water supply and its distribution. In October, 1899, the committee learned of the presence in San Francisco of Engineer Rudolph Hering, of New York City, and he was engaged to come to Sacramento and look into our projects and to report the result of his examinations to the committee so far as he might feel warranted in so doing at that time. His views and recommendations will be found among the reports of engineers. Upon his recommendation the committee proceeded to make a practical and exhaustive test of the East Side Wells for the purpose of developing the quantity and quality of the water from that source, a detailed report of which was made by the sub-Committee on Wells on March 2, 1900, and a final report submitted in November. The sub-Committee upon Sacramento River submitted a plan for filtration and a report thereon March 6, 1900. This plan embraced the plant of the present water works, but the proposition was afterwards considered to be insufficient to meet the future wants of Sacramento and that a more advantageous site was desirable for the location of the proposed new works. Perfect filtration being deemed possible and the Sacramento River offering many advantages as a source of supply, another locality was selected and a plan and report by the sub-committee was submitted later on. During the months of March and April, 1900, the committee again conferred with Mr. H. Schussler and by his invitation several members visited the Spring Valley Water Works and were courteously received by Mr. Schussler and shown over nearly the entire system of the above-named water company and its operations and many of its details were fully explained. The developments and results obtained by said company at Lake Merced led the committee to believe that similar results might be produced at or near the junction of the Sacramento and American Rivers, thus avoiding the cost of filtration as well as securing a water supply near the present inexhaustible source, where the Sacramento River would always be available in case of possible failure elsewhere. Accordingly, and, after considerable unavoidable delay, land was bonded and the work of boring wells to ascertain results thereon was performed during the months of July and August, 1900, under the direction of the sub-committee appointed for that purpose, P. C. Drescher, Chairman. The quality of the water developed in this locality was found to be undesirable and this project was thereupon abandoned. (See analysis and report of sub-committee.)

The sub-Committee on Mountain Supply filed its report November 22, 1900. The sub-Committee upon American River and North Fork Ditch filed its preliminary report June 5, 1900, and its final report March 27, 1901.

In October, 1900, the sub-Committee upon Sacramento River having found its preliminary report unsatisfactory for reasons hereinbefore stated, asked and obtained authority from the General Committee to employ an engineer to prepare a new plan and estimate. Mr. Walter Wagner, of Chicago, was chosen for that purpose and in a conference with the sub-committee in January, 1901, new surveys were made and he was instructed to prepare plans, specifications and estimates for a filtration plant, with pumps complete, to be established upon land selected by the sub-committee and located north of Slater's Addition and near the junction of the north levee and the Sacramento

River. His plans and estimates were received by the sub-committee February 28, 1901, and immediately taken up by said committee. His estimates were verified by those secured from local contractors and others, and the committee's final report was submitted and filed March 27, 1901.

The preliminary reports of Messrs. Rudolph Hering and L. J. Le Conte, together with all the reports of the sub-committees are herewith appended.

Preliminary Report of Rudolph Hering.

SAN FRANCISCO, October 23, 1899.

General Lewellyn Tozer, Chairman of the Water Committee of Sacramento, California—Dear Sir: In compliance with your request to visit your city, examine into certain projects for a new water supply and advise you regarding further investigations, I hereby report as follows:

On my arrival you stated to me that you desired the entire water problem looked over and an opinion given as to which of the available projects for securing a better supply should be further investigated, and if so, to indicate the character of such investigations. For this purpose you gave me to look over, several previous reports that had been made, suggesting certain new sources of supply.

October 20th, 21st and 22d were spent inspecting the present works and, so far as it was possible within the limited time of my visit, examining into all of the projects that had been suggested to obtain a better supply, and conferring concerning them with the gentlemen of your committee.

On the 20th I examined, with several members, the point of confluence of the American and Sacramento Rivers, the present pumping station and the territory suggested for securing a ground-water supply southeast of the city. On October 21st I was shown the works of the North Fork Ditch Co. at Folsom.

On the 20th the Sacramento River was running fairly clear, but the American River was turbid. The rains of the following day caused the Sacramento River likewise to become turbid and to rise to the gauge hight of seventeen feet. It was stated that the quality of the water was then almost equal to its worst, so far as turbidity was concerned.

The present water supply of the City of Sacramento is taken from the Sacramento River in front of the city about half a mile below its confluence with the American River. At the pumping station this water is forced into the city mains for distribution. There is no reservoir nor stand pipe in the city, the system of distribution being that of direct pressure.

The pumping station contains one 5,000,000 gallon Allis pumping engine, which is new and apparently doing good service. There is also a 5,000,000 gallon Holly pumping engine, said to have been erected in 1872. This machine is old and is reported as not being in proper condition on account of its age. There is another pump in the building of about the same capacity, but it is reported to be entirely worn out and not in use.

The amount of water required in the city per day varies according to the season. It was stated to me that the average consumption in Summer was about 7,000,000 gallons per day and in Winter about 4,000,000 gallons per day. Inasmuch as these quantities do not contain an allowance for a slip in the pump cylinders, they are therefore excessive.

The station further contains three boilers carrying about ninety-five pounds of steam and said to be in good condition.

The safe capacity of the pumps is reported to be insufficient for the Summer supply and the old pumps should therefore as soon as possible be replaced by at least one new one.

The chief trouble from which the city is suffering at present is the turbidity of the water during most of the year. It is therefore desired, either to get a new supply furnishing clear water or else to purify the present supply.

The analyses of the water of both rivers show it to be practically free from injurious organic pollution. After filtration it is very palatable. An exception is made, however, in the case of the Sacramento River when, after a large area of low land has been flooded, the water recedes. It has then an unpleasant vegetal taste, no doubt due to its contact with the vegetation of the flooded land. The analysis further showed that by far the greater part of the suspended matter causing the turbidity is of mineral character. Most of it subsides quickly when the water is at rest. Some of it, probably being fine clay, remains to leave the water discolored for at least several days.

There is no noticeable difference in the taste or in the hardness of the waters of the two rivers; in both of them it is quite soft. Its quantity is ample at all times to supply the city with water.

The following projects or propositions have been suggested to improve the supply:

First—The Sacramento and American Rivers are to be used as the source, the water being taken at or near their junction above the city.

In order to render this water satisfactory, it is necessary to filter it at all times, and during most of the year to cause it to pass also through settling basins, in which the heavier suspended matter can subside before the water is taken by the filters. All of the water would require to be pumped.

Second—Southeast of the city, experience with wells has indicated the existence of a possibly large supply of ground water. This water is found at a depth from twelve feet to 100 feet below the surface, under an impervious stratum. Numerous analyses have been made of it and most of them have revealed a water of good quality. It is harder than river water, but not hard enough to be objectionable for domestic purposes.

No proper and sufficient examination has as yet been made of the availability of this source to supply the City of Sacramento. Presumably there is, as in similar locations, a deep stratum of gravel and glacial drift extending from the foothills into the plains and bearing a current of water, which, if it is of good quality and of sufficient quantity, can furnish a good domestic supply.

The original source of all ground water is the rainfall. The falling water partly runs off on the surface immediately into brooks and rivers, and partly percolates into the ground and flows beneath the surface to a natural outlet. If the ground is porous it can hold and pass a large quantity of water. If there is a continuous percolation from the rainfall and a continuous discharge of the ground water into watercourses, lakes or the ocean, there is established a permanent underground flow of water, which in numerous cases has been utilized for supplying cities.

The principal advantage of such water is that organic impurities have been naturally filtered out of the same, and that it has become spring water. Sometimes mineral impurities are dissolved by the percolating water, making it either hard or giving it an objectionable taste.

In the present case the analyses do not indicate that the water is objectionable for the city's use. This statement will, however, remain true only if the large quantity required by the city does not introduce unknown conditions which may affect the quantity of its mineral constituents, and true only if no polluting organic matter is hereafter discharged into the ground water through deep cesspools drained into the water-bearing strata.

As it is not probable, however, that either the hardness or the organic pollution will be increased beyond that shown in the present analysis, but rather diminished, this source of supply is also one which should be investigated. The ground water, of course, requires pumping, but no other treatment. It is therefore a less expensive supply than the river water, which, besides pumping, needs filtration.

Third—The North Fork Ditch Co. proposes to furnish the city, from its ditch near Folsom, a supply of 1000 miner's inches, or about 15,000,000 gallons per day. This water is now delivered at a night sufficient to allow it to flow to the city by gravity through a pipe line and under a pressure of about 150 feet. It would require filtering to render it acceptable. Probably there is but little, if any, difference in the expense of filtering the water coming from the North Fork of the American River or of filtering the water of this river at Sacramento.

Fourth—A further proposition has been made, in case the quantity of ground water should be found insufficient for the entire supply required by the city. It is then proposed for economical reasons to furnish such quantity as may be available and to supplement it by the continued use of the river water at the city, but after it has been purified by filtration.

Fifth—Still another proposition has been made, namely, to obtain clear and pure water directly from the mountains at the nearest available locality and to bring it to the city in a pipe line by gravity under a sufficient head to answer all practical purposes.

The filtration of water is a subject about which now much more is known than a few years ago. It has become possible to arrange filter plants so that the effluent water can be given any degree of purity that may be desired. There are, generally speaking, two methods in use—the slow and the rapid filtration.

The slow filtration requires a bed of sand several feet thick and arranged in specially prepared basins, having an impervious bottom and sides. The water is allowed to percolate through this sand and escape by specially arranged drains at daily rates varying from five to ten cubic feet per square foot of filter surface. Various appliances are necessary to insure a proper rate and to enable a top layer of sand to be removed when it becomes clogged, to wash the sand thus removed and thereafter to redistribute it upon the filter.

The rapid filtration requires tanks made of wood or iron and supplied with mechanical appliances to wash the sand in the tanks. These rapid filters are intended daily to clean about 300 cubic feet of water on every square foot of sand surface. In order that this rapid percolation may be accomplished, and yet effectually cleanse the water, it is necessary to use a coagulating material, such as alum, in order to have on the surface of the filtering material a film which retains the bacteria and finer particles of suspended matter.

There are other, but minor, differences between the slow and rapid filters which it is not necessary to enter into at present.

Prior to the successful operation of either, it is necessary to allow for a sedimentation of the heavier suspended matter. This is accomplished, in the case of slow filters, by allowing the water to enter large settling reservoirs, where it can obtain a state of comparative rest. The suspended matter then naturally settles to the bottom. In the case of the rapid filters, there is a mechanical contrivance in use in some of them which accomplishes a similar result in a smaller space and in direct connection with the filters.

A final comparison of the different available projects should be made along three lines of inquiry, namely: First, the quality of the water to be furnished; second, the quantity of water obtainable; and third, the cost of building the necessary works and of operating them.

QUALITY.—In the case of the river waters, there seems to be no indication that they would not be suitable for the city's supply. A sewage pollution is and will be almost absent and nearly all of the suspended matter is mineral. A clarification of the water is therefore the main object to be secured, rather than the purification of water polluted with foul organic matter. For such a purpose, there is no difference between the results of the slow and the rapid filtration, and both these methods may, in the present case, be considered as having equal merits from a sanitary point of view.

The known geological and topographical features of the water sheds of these streams indicate that the water should have a good quality for municipal purposes. The mining industry causes much of the turbidity, and perhaps some slight chemical change, but adds no sanitary impurities.

If the analysis of the ground water, after long continued pumping, shows results equal to those heretofore obtained after long pumping, the quality of the ground water supply can be relied upon as being satisfactory. Inasmuch as this water has been clarified by a natural process, such a supply is therefore ordinarily considered preferable because more reliable than one which requires an artificial process.

While the water from mountain streams, when it is naturally clear, will also generally be pure, it will not always be free from pollution, owing to the fact that it is at least exposed to the incidental defilement by animals and human beings. A ground water supply or one that has been artificially filtered can be guarded against every subsequent pollution.

QUANTITY.—There is no question that either the Sacramento or American River has a sufficient quantity of water during the driest year to supply the needs of the City of Sacramento.

The North Fork Ditch Co. offers to deliver 1000 miner's inches, or 15,000,000 gallons, daily to the city. This quantity is stated to be one-third of that which is made available by the ditch.

Regarding the quantity of water obtainable from the ground water supply, it must be said that there is insufficient knowledge to foretell how much water could be permanently drawn therefrom. The indications are that a supply of considerable magnitude may be available. A city should, however, not rely upon such indications until the actual minimum supply has been demonstrated by a proper test.

Regarding the supply of pure and clear water from the mountains, it would be necessary to have a determination of the minimum flow during the driest years. Should this flow be insufficient, then it would be further necessary to investigate sites for storing the larger flow of water during the wet season, so that it may supplement the insufficient flow during the dry season.

COST.—After the best of the above-mentioned projects have been ascertained, so far as the quality and quantity of water which they will yield are concerned, it is then necessary to make a careful estimate of the cost of each one, including different methods of filtration, so as to ascertain their relative economy. In order to be of value, such estimates of cost should be based on good judgment, experience and, when necessary, on surveys and other practical physical examinations.

A comparison necessitates first the making of an estimate of the entire cost of building the works, including the purchase of land, water rights and other contingent expenses. It is then necessary to compare the projects as to their total annual cost, which must be made up of the following three items:

a. The interest on the cost of the works.

b. The depreciation per annum of the different parts of the works, some, such as structures of masonry, have a long life; others, like timber, iron or steel pipes laid in the ground, machinery, etc., perish in shorter times.

c. The operation and maintenance of the works. This item should include the cost of supervision and inspection, the general care of the works, the making of small repairs and also all contingent expenses. It should further include, wherever required, the expenses for pumping and for purification; also any royalty or annual charge for the use of ditch water, in case such water is used.

To point out more specifically what needs to be done to ascertain the relative merits of the several propositions considered, it may be well to add the following remarks.

In order to have sufficient and reliable information for getting the necessary capacity of settling reservoirs and filters, in case either the Sacramento or American River or North Fork Ditch water is used, observations should be made regularly during the coming Winter, perhaps twice a week, of the amount of sediment that is carried by the water. Such observations, for the purposes of comparison, are best indicated in parts of residue precipitated from a million parts of water.

The project to utilize the water of the North Fork Ditch Co. should be investigated sufficiently to ascertain whether or not the quantity of water to be furnished by the ditch would be permanent as to natural artificial and legal causes.

A city should, if possible, control its own water supply as far as its natural source. It would be a serious matter should there be an accident along the ditch or along the pipe line between Folsom and the city. A reasonably safe guarantee would include a duplicate pipe line from the dam to the city. A single pipe line between Folsom and the city might afford less risk than a single ditch between the dam and Folsom.

Still, the importance of a city's water supply makes it desirable, if possible, to have more than one pipe line.

In order to determine the quantity of water available below the surface of the territory southeast of the city it is necessary to make a thorough and systematic test.

In the first place the present level of the ground water should be ascertained as soon as possible, as this fairly well indicates the minimum supply, because the past season has been one of phenomenally slight rainfall.

Levels of the water should be taken with considerable precision in as many of the private wells as possible for a distance of several miles from the city. They will establish the level of the plane of water, and indicate the slope of this plane, and therefore the fact as to whether or not there is a flowing subterranean stream. They would also indicate the direction from whence the water comes. Having found good reasons for believing that there is a considerable flow, then it would be necessary to sink several pipe wells near the city on a line at right angles to the direction of the underground flow and at such distances apart and in such numbers as may be found necessary.

The depth having been estimated, at which it is probable that the water will stand when pumped, it may then be found necessary to dig a trench into which to lay the pipe connecting the wells with the test pumps.

These pumps should all be operated together, without interruption and with a constant discharge of water, passed through a flume and measured over a weir.

Before the test is made small tubes should be sunk at such distances apart as may be found necessary and in the direction from where the water flows. These tubes must be sufficiently deep to allow the distance to the surface of the gound water to be accurately measured These measurements should be made regularly during the time of pumping and the changes carefully noted.

Such an investigation, if properly conducted, will make it possible to ascertain the greatest quantity of water that can be drawn from the ground perpetually; provided, that during the pumping the water level in the test tubes remains constant for perhaps a mile or more in the direction of flow.

As such a test cannot be made until the ground water level has risen above what it was at the end of the late dry season, it will be necessary to exercise careful judgment regarding the relation of the increased flow to the increased pumping during the test. It is very important, therefore, to ascertain the level of the ground water at the present time before it has been materially changed by the rains.

In case it is found that the ground water supply is insufficient in quantity to supply all the water needed by the city, it may still be economical to erect an auxiliary pumping station southeast of the city and obtain from this source as much ground water as is available. Then the investigation should be continued by ascertaining the cost of filtering the remainder of the necessary supply which may be obtained from the rivers.

If the above test is made with reference to the condition of the dry weather flow, existing at the end of the dry season, there is no force to the objection that subsequently such a supply may fall off in quantity. This fear might only be entertained if the water filtered into the ground from the American River; for the suspended matter carried by it might close the pores and gradually reduce the flow through the same. But a natural ground water flow between the city and the mountains, and which may be entirely independent of the flow in the river, will not be reduced by clogging.

The preliminary examination of taking the water levels in existing wells, will indicate whether much ground water now flows into the American River and thus might not flow to the pump wells near the city.

If deep cesspools or other means of affecting the ground water supply are prohibited by law, there is no probability of a future pollution of this source.

To prevent polluted surface water from running down the sides of the tubes through which the water is pumped the city should own a strip of land upon which these tubes are placed.

Among the investigations to be made it might also be well to ascertain the feasibility of getting a supply of clear and unpolluted mountain water. From the information I have received, it appears, however, that such a supply would be more expensive than some of the others which have been above discussed.

-In providing for a new and better water supply, and when estimating the comparative cost of competing projects, there should be included in those projects requiring pumping, sufficient pumping machinery, so that one of the pumps can be out of service at any time for repairs. To depend upon an almost continuous working of all of the machinery is a risk which a large city should not take.

Whether the water is taken from the ground, or whether it is filtered at the city, or whether it is brought in a conduit line from Folsom, it is in every case advisable, in my opinion, to provide a clear water reservoir of sufficient capacity to compensate for the irregular daily draft or consumption. During the day time much more water is used than at night and when there is a fire a sudden demand is made for a larger quantity. A clear water reservoir should hold from one-quarter to one-half day's supply, and will be of more value in or near a city than if it is twenty miles away, because the variation in the consumption or draft can be more readily satisfied.

The clear water reservoirs, whether they contain ground water or filtered water, should be covered so that the water is protected from a pollution by dust or the growth of algae, giving the water an objectionable taste, a common occurrence both in ground waters and in filtered waters.

In conclusion, and in view of what has been stated above, I would recommend to you that:

As the ground water supply seems to indicate the availability of enough water to supply economically at least a portion of the city, a test of the same should be made at the earliest possible time. Besides ascertaining the available quantity, there should also be made a chemical test of its quality when the greatest quantity is pumped.

To be in possession of the desired data, in case it is found necessary to use river waters, the amount of sediment carried in the water during the Winter should be measured as frequently as possible, and particularly at such times when the amount is greatest; that is, when a high degree of turbidity prevails.

After conducting the above tests it will be necessary to make surveys and plans for whatever projects will then appear to be most economical, and to make the estimates of cost in such a manner that not only the first cost but all the annual expenses incurred are properly presented. To conduct such an investigation as above outlined in an effective and economical manner requires the skill and close attention of an experienced and trained engineer, such as there are several available in your neighborhood. Very respectfully,

RUDOLPH HERING,
100 William Street, New York, N. Y.

Preliminary Report of Committee on Wells.

SACRAMENTO, Cal., February 26, 1900.

To the Citizens' Water Investigation Committee of the City of Sacramento: Your Committee on Wells beg leave to submit the following report on the test of the wells one mile southeast of Sacramento:

In the latter part of October of last year, Mr. Rudolph Hering advised you that a survey of the ground waters adjacent to Sacramento should be made and, if the survey showed there was a flow from the direction of the mountains, a test should be made to determine whether or not it was of such a volume as to warrant your recommending its use as a source of supply, or partial supply, for Sacramento City. His advice was that if a flow was found of sufficient volume to warrant the construction of the necessary plant, it would save filtration to the extent of the supply developed.

Under your instructions, the Committee on Wells proceeded at once to have the survey of the ground water made. That being made, as it happened, at the end of two phenomenally dry years, gave us a record of the lowest ground water that has ever been known. This can be compared with the state of the ground water hereafter, if desired.

The survey was made under the direction of L. J. Le Conte, C. E., of Oakland, who reported that the results indicated a flow of water from the direction of the mountains. He advised that a test be made at the Kellogg place adjoining Oak Park. You then instructed our committee to proceed with the test in hopes of completing it before the low stage of the water—ground water—could be materially affected. The preliminaries, including the time consumed in getting the privileges desired of land owners, delayed us until the middle of November. The authorization of the test having been delayed until so late in the season, it became necessary to get privileges on land that would permit of a test being postponed until next Fall, if found impracticable to complete the test this year. We found property owners averse to giving extended privileges on land that were considered by us important, and in other instances we found the underground formation unfavorable to completing wells in time with the means at hand. Had these conditions not prevailed, the test would have been made farther east.

The reasons for taking the Kellogg place may be summed up as follows:

Privilege was obtained for a period long enough to enable us to complete the test.

The cost of the privilege was more than offset by the value of the two wells on the place.

These wells had been tested by the Sacramento Chamber of Commerce in 1898 with results indicating an underground flow of water of good quality and large quantity, thus rendering the probability of having to abandon the test here and repeating elsewhere exceedingly remote. Had a test been made in some other locality with different formation, and the quantity and quality found to be more unfavorable than at the site of the Chamber of Commerce wells, there would have been a doubt as to the wisdom of the selection. The difficulty of obtaining authorization for the present test was such as to indicate that any doubt might never be cleared up by another test.

We found the well borers willing to bore wells on the Kellogg place on a contract, while at other places they would work only by the day, or at prohibitory rates, because of unfavorable underground formation.

A further reason for locating at the place chosen was that the matter of getting rid of the water seemed to present less serious obstacles at this point than at any of the other available locations. Even as it was, there were objections made at the last moment after it was too late for us to retreat. The committee had taken the precaution to have the route of the water channel inspected, and received a report to the effect that there would be no damage, as the water would be conducted through the drainage canal to tide water. This channel is often used to conduct many times the quantity of water pumped at the test. In fact, any damage could be only imaginary, the thought of it being induced by the misconception of the quantity of water used by Sacramento City—a small quantity as compared with that carried by the drainage canal after a storm.

When all was ready, a delay in an attempt to avoid threatened injunctions caused the test to run into a storm which stopped the trial on the third day. All these troubles might have been avoided to some extent had the test been made during the dry weather. The handicap of time and weather not only rendered results less satisfactory, but they were obtained at a cost of considerable more than would have otherwise been necessary. At one time the committee debated seriously the question of postponing the pumping until next year, but by the time this problem presented itself there had been great expenditure in installing the plant, which would have had to be dismantled and returned to those from whom it was borrowed. We determined to go on with the test because the cost of completing it would be smaller than the loss which would be caused by taking out and returning the pumps and engines. It was further considered probable that there was less water flowing underground than there would be next Summer, because of the melting snows resulting from a hard Winter.

The wells used were seven in number, southeast of Thirty-first and Y Streets, and exactly one mile distant from that point. A description of these wells and their location accompanies the report of Mr. L. J. Le Conte, which report we attach herewith. (The wells were designated by numbers from south to north and will be referred to according to their numbers.)

Mr. Le Conte had recommended boring a number of wells and connecting them through a tunnel thirty feet below the surface, and setting the pumps at that level. His attention, however, being called to the fact that this could hardly be done within the limits of the time and money available it was decided to sink seven separate wells and install a pump and engine at each. Another reason for this decision was that threshing engines seemed to be the only available power. It was our desire to use electric power, but after considerable investigation this was found impracticable because of the expense involved and the impracticability of obtaining power day and night at this point.

Suitable engines, at reasonable rates, were rather difficult to obtain, and this feature, together with the short time available to complete the wells, determined the limit of the quantity of water that we endeavored to develop. This was placed at the maximum amount now used by the city.

The wells were bored over a limited area, under the theory that if sufficient supply were developed from limited ground for the present requirements of the city, the future increased supply could be obtained by extending the system of wells. The extent of the plant was based on the estimate of the pump manufacturers of the capacity of the pumps, and the amount of power necessary to supply the desired amount of water under conditions which we approximated very closely. It was found that the pumps and power had to be perfect to equal the estimate, but one well out of the seven being made to yield the amount desired. This, however, was enough to show that it was more a question of power and pumps than of supply of water in the ground. One other well was taxed to its full limit, but was handicapped by being one of three wells within a space of 100 feet across the supposed line of subterranean flow, the other four wells having been allotted 200 feet each. This well was also cased off deeper than any of the others except one, being thus deprived of the flow of ground water except that between 75 and 114 feet; this well had ample power and pump while the pump worked. The pump did not, however, work more than half the time, thus reducing the average output of the wells. The well fifty feet north of this, and the center well of the three that were within the space of 100 feet, was operated continuously during the experiment and taxed the capacity of the engine which operated its pump. Undoubtedly these three wells within the limited space, and near the center of the whole line of wells, taxed the ground supply more than at other points and thus caused a deeper depression of the ground waters at this point, and a consequent overtaxing of the power of the pumping machinery. It is safe, however, to estimate that these three wells yielded from within a space of 100 feet across the line of flow, one-third of the water pumped from the seven wells. As the ground water to the north and south of this group of three wells was presumably drained by the other pumps to such an extent that this group could not have had an advantage, but rather a disadvantage of location, it is safe to presume that, if the space of 900 feet, which was occupied by the seven wells, had been occupied by nineteen wells fifty feet apart, there would have been an increased yield of the water whose total volume would be expressed by figures somewhere between the total actually pumped and about double that amount, without depressing the water level at the line of wells materially.

With the exception of the conditions as to the group of wells just noted, and which were known as Nos. 4, 5 and 6, the other conditions were about the same, excepting that No. 3 was a deep well, being bored to a depth of 189 feet from the surface and cased off to a depth of 165 feet, thus causing the supply of water to be drawn wholly from the deep strata. The other wells were cased from 45 to 65 feet, and this was cased deeper in order to permit of samples being drawn from deep and shallow wells while yielding water simultaneously, thus determining the difference in quality between the two depths of water. Casing off so much of the well limited the number of water-bearing strata to feed this well, the same as it did in the one mentioned above, and also increased the friction by causing the water to flow through the long tubing, but this also acted to keep the flow in the well active, so as to cause a continual pumping of sand and a consequent improvement of the well all the time it was pumped. The result was that this well yielded more at the end than at the beginning of the test. The disadvantages as to quantity were more than offset by the advantages of determining the quality and the fact that the deep strata will afford a quantity of water, for this well yielded approximately its share at the end of the experiment regardless of being dependent on but one stratum of water-bearing sand. The analysis as reported by your Committee on Purity shows that this water is good, though containing two grains to the gallon more of inorganic matter than the other water. If it should be considered that the advantage, whether sentimental or otherwise, of obtaining deep water more than offsets the disadvantage of the extra two grains of unobjectionable salts, then this demonstration might be enough to warrant casing off permanent wells to a depth of 150 feet and making the attempt to get volume from the deep strata. Should this be proven to be impossible, the casing could be punctured to admit water from the upper strata and very little lost in the attempt.

The test was made under the theory that there was communication between the different strata, and no attempt was made to shut off the upper waters perfectly. It was expected that the ground water near the surface would be affected in the immediate vicinity of the wells. Test wells were bored and private wells availed of to determine by frequent measurements the actual effect on these wells. Mr. Hering's report, which was the basis of our operations, indicated that wells would possibly be affected at a distance of a mile or two east of the pumps within three days. The wells that were affected began to be affected the first day, but the limit of the distance at which the affect was appreciable was about 2000 feet; at 2500 feet the affect was hardly appreciable. In other words, six days' pumping did not affect wells that were over half a mile away. The affect being greatest the first day or two, it is reasonable to conclude that the supply which was drawn from waters near the surface in the immediate neighborhood was exhausted during the first few days, and the supply to the wells was through the deep strata of loose sand which strata were tapped by the wells. Any of the upper ground waters which reached the pumps thereafter had to do so by filtering through nearly half a mile of compact ground, besides sinking to a depth of twenty-five feet, which was the level of the water in the ground at the line of wells on the sixth day, the ground above this being at that time drained by previous pumping. The fact that the affect on the ground waters was slower than anticipated indicated a close rather than a loose formation of the ground, and the area of material depression indicates the amount of ground that it would be advisable for the city to control to have almost absolute protection.

The pumping plant was installed on the basis of the estimates of the pump manufacturers for raising 10,000,000 gallons forty feet every twenty-four hours, and with the expectation of raising about 7,000,000 gallons, as is probably the maximum now used by the city in a day. The inability of the average threshing engine to develop twenty horse power, the excessive casing of the two wells as noted above, but mostly the seeming impossibility of keeping the pumps properly packed while operating under a strain of deep suction, limited the output at any time to five and one-half or six million gallons at most. This was the first day, when the water levels were not as much depressed as latterly, and estimates are made from measurements at the main measuring box the first day as compared with measurements at the same box which were made afterwards and estimated by Mr. Le Conte at four and a half and five million gallons per day. Mr. Le Conte was not here after the fourth day, but his measurements on the last day he was here showed a flow of 5,000,000 gallons, demonstrating that there was practically a constant flow after the upper ground waters were drained off.

The water was all run through one box and estimates of the quantity pumped were made by Mr. Le Conte. There were also rough measuring boxes at each of the wells to get at the comparative results.

The pumping was started January 31, 1899, but was discontinued on the third day because of a storm. It was resumed at noon, January 10, 1900, and continued until 3:50 p. m. of January 16th, or a little over six days. Observations were made frequently as to the effect of the pumping on the ground waters to the east, for the first few hours of pumping and likewise for the first few hours after stopping. Later observations were taken at regular intervals. Observations were also taken of water in the neighborhood. The principal observations were taken at the line of the wells, at 440, 880, 1500 and 2500 feet to the east of the center line of wells.

The affect at the wells was nearly at the maxim the first day, and at 2500 feet there were three wells some of which did not show any affect and in none was there any appreciable affect. The following table will show how much the water was lowered in each test well on the different days:

Well 440 feet east—First day, 66 inches; second day, 10 inches; third day, 8½ inches; fourth day, 9 inches; fifth day, 5 inches; sixth day, 1 inch. Well 880 feet east—First day, 15 inches; second day, 8 inches; third day, 7 inches; fourth day, 5 inches; fifth day, 5 inches; sixth day, 5 inches. Well 1500 feet east—First day, 16 inches; second day, 4 inches; third day, 3 inches; fourth day, 2½ inches; fifth day, 2½ inches; sixth day, 2½ inches.

There was no fall in water in the wells a mile to the east The total fall for the six days was 13 feet at the line of the wells; 8½ feet, 440 feet to the east; 3½ feet. 880 feet to the east; and 2½ feet, 1500 feet to the east. A well 200 feet to the south of the pumped wells fell about as rapidly as the well 880 feet to the east. A well about 2000 feet to the southeast fell a total of one foot. The depressions were seemingly greatest in the supposed line of flow, and reasoning inversely, the line of flow would have been from a point a little to the south of east.

Having been notified of the time fixed for an injunction to be served, and feeling that the water in the test wells would not be brought to a standstill by that time, we conceived the idea that it would be well to ease off on the pumping and be sure of 4,000,000 gallons per diem rather than be in doubt of 4,500,000, as we supposed we were pumping, or 5,000,000, as actual computation by Mr. Le Conte determined for us afterwards. With this end in view, we had the pump on Well No. 3 stopped on the morning of the last day. We were aided in this idea by the accidental breaking down for a short time earlier that morning of the engine at Well No. 7, so that there was one well less being operated for about the last twelve hours. Some of the other wells seemed to be yielding rather more than usual the last day, and, considering that between repairs to engines and pumps the average was only about five and a half or six pumps running on previous days, the diminution on the last day was probably not as much as necessary to produce the effect desired, but it was enough to show that the water in the 440 foot well actually rose for a period, fluctuating, however, so that the total affect from 5 p. m. of the night of the 15th until the pumps stopped at 3:50 p. m. of the 16th, was a raise of about a tenth of an inch, while the total decline for the twenty-four hours was about one inch. This means the water in this well was practically at a standstill. That the water in the well 880 feet to the east was not affected this way can be explained by the fact that even when the pumps were all stopped there was no affect on this well for several hours, and only three inches for the first eighteen hours. For the first half hour after the pumping was stopped, measurements were made every five minutes in Well No. 3 and in the test wells 440 and 880 feet to the east. Thereafter measurements were taken at intervals for four days. The water rose very rapidly at the line of wells and at the 440 foot well; it was so rapid at the line of wells that it was not long until the water here was practically at a level with that 440 feet to the east. This indicates that the supply came in faster from the underground channels and filled up the center of the depression rather from the wells than from the outer boundary of the basin. For the first few hours water was draining from the 880 foot distance, so that this did not fill up at this point, but when it did begin to fill it filled about as rapidly as it did at the 440 foot point.

Our committee preferred to leave the conclusion as to the indication for permanent supply to the consulting engineers, and we have suggested only such thoughts on the subject as occurred to the committeemen themselves as being helpful to each of you to draw your own conclusions from the data obtained.

When Mr. Rudolph Hering was here last Fall he kindly offered to give us further information, if we should submit a report of the results of our work. Accordingly we gave him a detailed description of the work of the committee in exploring for well water. Tabulated measurements of the affect on the water in the different wells were sent him so that he would be able to draw his own conclusions. We quote as follows from a letter just received from him:

"I am delighted to read that the experiments which you made have proven both that the ground water is of good quality, and also that there is at least a sufficient quantity available to justify the building of new works for a supply of filtered water southeast of the city. The results are satisfactory, although it was unfortunate that pumping could not have been continued a day or two longer. Nevertheless, the results have proved to my satisfaction that there is enough water available to justify the erection of a station. It appears, from Mr. Le Conte's letter, that you will certainly get a large supply by extending your pipe line, and also deepening the plane from which the water is drawn up. It is, therefore, likely that you will have enough water to supply the city at the present time. There is, however, apparently a close margin, and it may, therefore, not be far off when you will also have to filter some of the river water to supply the deficiency."

The matter of the quality of the water has been left wholly to the Committee on Purity, to which committee we explained the difference in depths and conditions of the wells.

The cost of the experiment, including preliminary surveys, superintendency, services of Mr. Le Conte and option on land was about

$6400. All left-over tools, belting, etc., have been turned over to the city and stored in the Corporation warehouse.

The total time the pumps were operated was nine and one-half days, of which six were consecutive.

We estimate that a system of wells, duplicate pumping plant, consisting of two 10,000,000 gallon pumps and boilers properly housed, sufficient land and thirty-inch pipe to connect with the proposed city mains at Thirty-first and P Streets, would cost between $200,000 and $225,000. Should a site be chosen farther out, there would be an additional expense for pipe dependent upon the additional distance from the city.

These figures are intended to be approximate only, but are considered by us sufficient for comparison with other plans. Detailed plans would be expensive and will hardly be necessary unless the judgment of your committee is that the system of a water supply from wells seems preferable to other proposed systems. Respectfully submitted.

A. MEISTER (Chairman).
D. McKAY.
DOUGLAS A. LINDLEY.
HERMAN H. GRAU.
LEWELLYN TOZER
Committee on Wells

Report of L. J. LeConte on East Side Wells.

SAN FRANCISCO, Cal., January 29, 1900.

Mr. A. Meister, Chairman Committee on Wells, Citizens' Water Committee, Sacramento, Cal.—Dear Sir: In compliance with your request, I have now the honor to submit the following brief report on the final results obtained during the recent pumping tests, made under your directions, to determine the capacity of a series of wells, Nos. 1, 2, 3, 4, 5, 6 and 7, situated near the corner of Rose and Sacramento Avenues in your city.

The test for capacity began on the 10th inst. at noon and was completed on the 16th inst., at 3:50 p. m., at which time operations were brought to an end by injunction. The pumps were operated day and night continuously, with few minor interruptions.

The following is a list of the wells tested for capacity.

No. 1—8½ inches diameter, 190 feet deep, cased 52 feet.
No. 2—10 inches diameter, 130 feet deep, cased 46 feet.
No. 3—10 inches diameter, 190 feet deep, cased 160 feet.

No. 4—10 inches diameter, 114 feet deep, cased 46 feet.
No. 5—10 inches diameter, 114 feet deep, cased 46 feet.
No. 6—10 inches diameter, 130 feet deep, cased 46 feet.
No. 7—10 inches diameter, 130 feet deep, cased 46 feet.

PUMPS.—The seven pumps used were ordinary centrifugal types set down low in pits only twelve feet deep and practically at the existing level of the ground water. The pumps comprised:

Two 8-inch diameter discharge.
One 10-inch diameter discharge.
Four 7-inch diameter discharge.

They were driven by a proper system of belting leading up to ordinary portable engines of fifteen to twenty horse power each, except in the case of Well No. 4, where the 10-inch pump was propelled by two such engines.

The discharge pipes from the pumps were set vertically and emptied into a flume, the water column being forced up a distance of about fourteen feet to the outfall. The suction-head or lift increased with continued pumping and at the close of operations attained the depression of 22 to 28 feet below the ears of the pumps.

GROUND WATER DEPRESSIONS.

In all water supply testing operations of this character the great physical feature to watch with close attention is the ground water depressions due to a given draft of water at the pumps. The depression of the water level within the well-casings being a matter of little moment because it is very largely under your control. Two test wells were bored with the view of noting carefully the "drop" of the ground waters as pumping operations continued. No. 1 was 128 feet deep, distant 440 feet easterly, and No. 2 was 50 feet deep and distant 880 feet easterly from the line of the wells. In addition there were many private wells, situated to the eastward, which furnished good, reliable data bearing upon the affect of pumping on the level of ground waters at these sites.

The final results obtained at the close of operations may be summarized about as follows:

DEPRESSION OF GROUND WATER.

	Below Original Level.
At the line of wells	13 feet
Test Well No. 1, 440 feet distant	8.5 feet
Test Well No. 2, 880 feet distant	3.6 feet
Private wells, 2000 feet distant	0.25 feet

Private wells, 2500 feet distant............0.16 feet
Private wells, one mile distant.............Nothing

The original level of the ground water was twelve feet below the surface of the ground.

It is important as well as interesting to note the fact that the axial line of the depression, as a whole, has a general direction bearing nearly east southeast from the pumps. This fact, together with the further fact that the present mid-Winter temperature of the ground waters is from 65 to 67 degrees Fahrenheit, would seem to settle the mooted question conclusively that the ground waters discharged from the pumps are not derived from the American River sipage.

At the beginning of operations it was the settled purpose to continue pumping until the ground water stopped falling, or came to a steady stand. From my own observations, taken between the 11th and the 14th insts., inclusive, supplemented by Mr. D. A. Lindley's records, including the 15th and 16th insts., I am satisfied that the ground waters were at a stand from 5 p. m. of the 15th to 3:50 p. m. of the 16th inst., the draft of the pumps during this period of time being at the rate of 4,500,000 gallons per day and six wells going steadily. This quantity is the minimum supply during the last stand of the ground water, indeed, there are some indications of a rise in some of the wells due to the stopping of one of the pumps.

Previous to this stage of operations the draft of the pumps was considerably more than this, notably all day of the 14th inst., when the measurements averaged fully 5,000,000 gallons per day.

Judging from the above results and the very limited affects on the neighboring ground water, the writer is entirely satisfied that if the pumps had been set at a lower level, with suitable horse power, as suggested and recommended by your consulting engineer, Mr. Rudolph Hering, and myself, the final results in capacity of these wells would certainly have reached 7,000,000 gallons per day, without peradventure. I think the results are sufficient to enable you to determine the best policy to pursue as to future improvement in your water supply, which after all is the main object of the pumping tests, as I understand it.

In conclusion I beg leave to congratulate you, Mr. Chairman, in particular, as well as the entire committee, on the encouraging results obtained during your pumping tests, and to express regret that the Court should have found it necessary to interrupt the operations, a matter which was entirely beyond your control. Respectfully submitted.

L. J. LE CONTE, C. E.,
M. A. M. Soc. C. E.

Final Report of Committee on Wells.

SACRAMENTO, Cal., January 29, 1900.

To the Citizens' Water Investigation Committee of the City of Sacramento—Gentlemen: Your Committee on Wells has heretofore submitted detailed reports of its actions and investigations. In them you have a record of results obtained and phenomena observed as our work progressed. We refer especially to the report of the test of wells on the Kellogg place one mile southeast of Sacramento. That report dealt as nearly as was practicable in a statement of the facts of the case as we observed them. We now submit this final report, which will embrace such conclusions as we have drawn from our observations so far as those conclusions relate to an available supply of water for Sacramento City. The recommendations we make are conditional upon the well system being adopted as a partial or exclusive source of supply.

Our first work was that of a survey of the levels of the surface of the water in existing wells located east of Sacramento and out as far as Brighton or Perkins Station. We found that there was a slope to the plane of water levels of over four feet to the mile. The direction of this slope was a little south of west. For all practical purposes it can be said to slope in a direction parallel to the American River. In other words, the plane of the underground water levels slopes from the direction of the mountains east of Sacramento to the trough of the Sacramento Valley, namely, the channel of the Sacramento River.

This is indisputable evidence of a flow, or at least a percolation, of water through the ground from the mountains toward the river.

If a vertical cut could be made at a point such as Brighton, two miles to the east of Sacramento, and all the land west of that cut could be removed to a depth of 150 feet, thus producing the effect of a cliff or hill at Brighton, there would result at the first moment of the change a condition often seen in the mountains and commonly described as springs. Those who are familiar with the ground waters of this section can easily imagine how the water would ooze out of the face of this cliff at all points below a depth of about fifteen feet from its crest. Wherever the vertical cut mentioned had exposed strata of sand or gravel there would be springs indeed.

After the first moment, as the water came out and ran off, the upper water bearing strata of the cliff would be drained and the springs would diminish until only those were left which would be below a certain line where an equilibrium would be established between the force of the flow of the volume of water and the resistance to that flow of the water bearing sand strata.

Without pretending to accuracy, but simply as an illustration based upon the quantity of water we pumped at the Kellogg place, we can illustrate the effect by stating that, if this cut were made for a distance of 900 feet north and south and a canal that wide was extended down to Sacramento, the springs would emit a flow of 5,000,000 gallons a day, and would all be below thirty feet from the face of the cliff, and either in the lower face of the cliff or in the bottom of the cut. The water developed would flow toward Sacramento, where it could be pumped up into the river and flow on toward the ocean, the same as would probably have been its destination had it been allowed to pursue its natural course.

We have illustrated the subterranean flow in this way to relieve the subject of any prejudice that may exist against well water obtained from a district where the plane of water levels would be horizontal and the subterranean supply more in the nature of that from a lake There should be less prejudice against water which resembles that from springs, or when taken from a flowing supply.

It is well known that where rivers dry up, the flow under the bed of the river or adjoining lands continues. It is, therefore, evident that where the rivers have a perpetual flow, that of the ground waters will be perpetual also. The question is as to quantity, and it was the aim of the committee to make the test for quantity at the end of a very dry season, which was the second of that kind, and, as it happened, at the end of the longest dry spell on record hereabouts.

It having been demonstrated that there was a flow of water through the sand, gravel or cobbles underlying the surface of the ground east of Sacramento, and it being evident from the annual rainfall on the water shed which would feed the underground channels, that there was a large quantity of water flowing through the ground, the matter in which we were most interested was how much of that flow we could intercept within an area limited enough to render the work practicable

In a system of wells this area would be that of a vertical section across the line of flow for such a distance as we could afford to extend the wells and to such a depth as would cause the supply to be great enough without the necessity of lowering the plane of the ground waters to such a depth as would render pumping too expensive, or the depression so great as to drain too large a territory.

We found that seven wells extending 900 feet across the supposed line of flow yielded about 5,000,000 gallons of water a day after having been pumped continuously at that rate for five days. A relaxation of the pumping to any appreciable extent such as a half million gallons on the sixth day caused the water to rise in the ground at the line of the wells and at a point 440 feet to the east, where we located an observation hole.

This clearly demonstrated that the water was flowing into the depression so fast that any diminution of the rate of pumping caused the water in the basin or depression adjacent to the wells to rise and check the flow until a state of equilibrium was established between the inflow and the pumping.

It is reasonable to estimate that, if we can obtain a supply of 10,000,000 gallons per day at all, it can be obtained from a system of wells extending about three times the distance north and south of that taxed for 5,000,000 gallons. By increasing the number of wells within the 900 feet compassed in the test, we could have obtained more water, but the water plane under adjacent lands would have been lowered.

Therefore, though we could have pumped more water out of the 900 feet, it is more practicable for us to assume that we intercepted all the water flowing past that 900-foot section and for a small section to the north and south. Hence, we estimate that it would be advisable to control land for at least half a mile north and south, or, more specifically, in a direction directly across the line of flow or percolation.

The width of the strip of land necessary should be determined from the area of material depression observed in our experiment. The point 440 feet to the east at which was located our nearest observation hole, was apparently at about the border of this area.

Beyond the next observation hole, which was a sixth of a mile to the east, the six days' pumping did not affect the slope of the plane of the ground water enough to materially hasten the flow of water through the ground and, therefore, could not alter the effect of any natural filtration or screening to which the water would be subject in its flow. We, therefore, consider the depression outside of that distance practically immaterial.

We conclude that a strip of land a third of a mile wide would serve all purposes. This would make the total acreage one hundred. Anything over that would be advisable simply because any error of over precaution in the matter of the acreage could be measured in dollars and cents expended for unnecessary lands. Such an error could be corrected either by putting the surplus land to some practical use or by disposing of it whenever time had demonstrated its superfluity.

Fortunately, the section where there is the best prospect for a subterranean water supply is of little value for anything else at present, and a large tract could be obtained at small cost. The soil of this whole section is underlaid with hardpan of probable volcanic origin.

which is nearly impervious to water and so near the surface as to render farming unprofitable. This same impervious stratum would be, in some measure, a protection from surface contamination of the ground waters.

During our experiment the water on the surface and above the hardpan was not drained by the pumps, remaining during the whole six days within a stone's throw of the line of wells unaffected, while the ground waters underneath were affected from the first few minutes at the various observation holes 440 and 880 feet distant.

The possibility of breaks in this hardpan renders it useless to count on it as a means of absolute protection from surface waters, but it certainly tends to minimize the danger, which is not great at worst. It is well known that in this section of California it is only in exceptionally wet seasons, or in the low lands, that surface moisture penetrates deep enough to come in contact with or join the ground water, which would be depended upon for a supply from wells. The section southeast of Sacramento is particularly favorable in this respect, and it is to this feature we would look for safety from surface pollutions near the wells.

For some distance surrounding the wells, the continuous pumping would lower the ground water levels and make it more difficult than ever for surface water to penetrate deep enough to connect with the ground water. In fact, any surface water would have to penetrate the soil twenty-five feet at the line of the wells, and at least twelve feet at a distance from the wells, the same as if it were penetrating a filter, and even more slowly. All water outside of the land controlled by the city would have to filter or percolate through at least a thousand feet of earth before reaching the wells.

Rudolph Hering, in his letter to our committee, has said that the supply developed at the test was sufficient in quantity to warrant the erection of a pumping station. This was, of course, based on the supposition that the supply would be permanent and of acceptable quality. To explain the justification for such an assertion, it will not be necessary to say any more than that the interest charges on the capital invested in the system of wells and pipe to connect them with the city, together with the extra cost of running a separate station for a 5,000,000 gallon supply, would not equal the interest charge on a 5,000,000 gallon filter plant and the cost of filtering.

We will, therefore, base our recommendations on the theory that a minimum supply of at least 5,000,000 gallons can be obtained, and suggest that proposals for contractors for furnishing a well system be based upon the payment of the sum of $30,000, if the desired supply of 10,000,000 gallons is not obtained but a supply of 5,000,000 gallons or more is obtained. A sliding scale for each million gallons over 5,000,000 might be even better. In this way contractors would feel safe in bidding with a guarantee for a permanent supply and would add but little for hazard.

We have reliable estimates of the cost of a system of twenty to thirty 12-inch wells extending over 2000 feet, and connected with a common sump by a concrete tunnel, or by a pipe laid thirty or forty feet under the surface. Estimates vary from $60,000 to $90,000, and, if the contractor were assured of getting a quarter or a third of the contract price upon his developing half the quantity of water, he could afford to bid lower and the city would at least get a remarkably cheap system of wells, if 5,000,000 gallons only were developed.

We would suggest that a tract of 100 or 200 or more acres be obtained somewhere east of the location where we experimented or to the southeast of the city, and a system of twenty or thirty wells be established. These wells should be bored to a depth of from 125 to 200 feet, and cased with double casing about seventy-five feet with the inside casing extended to tap such strata between the seventy-five and 200 feet limits as may be deemed proper.

These wells should be equidistant and cover a space between 1500 and 2500 feet, and be connected by a tunnel thirty or forty feet below the surface, or by a large pipe laid at that depth. The contract might call for twenty wells in a space of 1500 feet with a proviso that, if they did not furnish a supply without lowering the water level more than twenty feet, the system should be extended by adding ten more wells, and extending an additional 1000 feet. It might even be that, if sufficient land is obtained, an auxiliary station with low service pump could be established.

All these wells should be connected with a sump suitable for receiving the water and a pit suitable for a high duty pumping plant of two 10,000,000 gallon pumps.

We estimate that sufficient land for a system of wells with guaranteed supply of 10,000,000 gallons, a building, a thirty or thirty-six inch pipe such as has been proposed for the extension of our city mains and connecting therewith at Thirty-first and R Streets, and extending from a point not to exceed two miles from Thirty-first Street, could be had for $150,000. A system of independent wells with individual pumps run by electric motors, together with a stand pipe and reserve steam developing electric plant, might be more economical because of local conditions.

We have enumerated these items for comparison with any system of filtration at the site of our present Water Works. The water in the wells being approximately as available for pumping into the city as is the water from the river, the same pumping machinery would be necessary in either case. If it happen that the plant for filtration should cost about the same, the saving in a well system would be the cost of operating the filters.

If it is not desirable to maintain a relief station at the present Water Works, the proceeds of the sale of the present buildings and contents and the value of the site proposed for filters could be deducted. Any estimates or suggestions we make should be submitted to a competent engineer and modified by him, as our committee has not gone to the expense of employing an engineer to make detailed plans. We deem our estimates and suggestions sufficient until the well system is settled on and the location selected.

We have not touched on quality, as the favorable report of the Committee on Analysis indicates that there can be no objection on that score. We might say, however, that the analysis indicates that we may have something even more desirable than river water. The absolute freedom of the well water from bacteria and organic matter must be weighed in the balance by you with the superior softness of the river water.

We call your attention, though, to the fact that the well water developed by our test is a soft water and not in the least objectionable on this score for drinking purposes. It is also good for manufacturing purposes. Anything that surpasses it must be exceptionally free from inorganic matter, whether in solution or in suspension.

We do not consider the matter of the quantity available, as that will be eliminated, if contractors will put up proper bonds to insure the city against financial loss. Our estimates include a sum to be paid to contractors to compensate them for the risk.

Our investigations have been confined to the section southeast of Sacramento. If, however, it is the desire of your committee to take cognizance of the preference of many citizens for river water filtered in nature, there is a field for investigation in the Sanborn well district, near the old Sacramento beet sugar factory.

We feel, however, that the river factor in any such system would be more sentimental than otherwise, and that it would be, in fact, a well proposition pure and simple and subject to the findings of this report except that it would be less expensive to connect from that point with the present system of city mains. If necessary to have part filtered and part well water, the location would permit of filters and wells being located at a common point.

As the estimates submitted above cover the land, wells and piping, together with proper foundations and housing for the pumps, the total cost for a system of wells can be obtained by adding $90,000, making a total of $250,000 for a complete plant. The city would then be provided with a complete well system and have in reserve the present crude system, which would be very acceptable in case of an emergency. To this cost must be added the cost of an extension of our city mains, which would be necessary under any circumstances. Respectfully submitted,

A. MEISTER (Chairman),
D. McKAY,
D. A. LINDLEY.

Report of Committee on Mountain Supply.

SACRAMENTO, Cal., November 22, 1900.

To the Citizens' Water Investigation Committee of the City of Sacramento—Gentlemen: We, the undersigned Committee on Mountain Supply other than American River, report that we have been unable to find any suitable supply of mountain water which could be piped to Sacramento at a satisfactory cost. Any sources of supply that have come to our attention would require many miles of pipe and an expenditure of millions of dollars, thus rendering them entirely out of the reach of Sacramento. Respectfully submitted,

D. A. LINDLEY (Chairman),
THOMAS B. HALL,
HOWARD STILLMAN,
Committee on Mountain Supply.

Preliminary Report of Committee on Sacramento River.

SACRAMENTO, Cal., March 5, 1900.

To the Chairman of the Citizens' Water Committee: Your sub-Committee on Sacramento River Water as a source of supply for the City of Sacramento respectfully reports:

SOURCE.

The source of the Sacramento River is well known; it is direct, open and subject to no entanglements, either public or private, therefore it is beyond dispute a safe source of supply for the present or future needs or requirements of the City of Sacramento, and the quantity and continuity of flow are unfailing.

QUALITY.

While the quality of Sacramento River water in its natural state is soft, pure, clear and wholesome—in fact, an ideal water for domestic uses and manufacturing purposes—in its present contaminated condition, to say the least, it is unsightly, unpalatable and seriously objectionable for either domestic use or manufacturing purposes.

This being true, the first question to be considered is, can this river water be delivered to the people of the City of Sacramento in a clear and pure condition? Although our work has necessarily been confined to observation, inquiry and the reading of published reports, we firmly believe the Sacramento River water can be rendered pure, clear and wholesome by the use of sand filtration.

METHODS.

Sand filtration may be divided into two classes—"artificial" and "mechanical." The former requiring a large area for sedimentation reservoirs and sand filtration beds, is altogether unsuited to the conditions existing on the Sacramento River, therefore we shall confine this report to investigations along the line of "mechanical" sand filtration of the gravity type.

RESULTS.

There is little doubt about the efficiency and success of mehanica filtration when properly installed. Reports from all cities where filtered water is used show a material reduction, if not a complete eradication of all typhoid or other fever cases.

A committee appointed by the Board of Trustees of this city, consisting of members of the Board of Health and Board of Trustees, to investigate the typhoid epidemic, took up the question of water supply for the city, and in its report filed August 8, 1898, many cities using filtered water were cited, showing the great benefits received from filtration, and in concluding the report the committee made use of the following language:

"To avoid future epidemics of typhoid, Sacramento must profit by the experience of other cities, and protect her water supply. Deep wells properly protected will insure the city against epidemics of water-borne diseases, and proper filtration of the river water will afford the same protection."

From tests made of Sacramento River water by mechanical filtration under the direction of the Board of Trustees of this city during the months of February and March, 1899, when a Jewell filter was used, having a capacity of 40,000 gallons in twenty-four hours, alum being employed as a coagulant, it was found that the water in its worst stages was made clear, bright and sparkling, and almost pure.

During the experiments with the filter, tests for disease germs in the filtered water were made by Doctors Power and Henderson, showing that nearly 99 per cent of all the germs contained in the water had been removed by the filter.

Mr. Howard Stillman, at the request of the Board of Trustees, made an analysis of this filtered water for the purpose of determining whether it contained alum, and his report shows that no alum could be found, while the water was free from all suspended matter, and perfectly clear. For the purpose of showing the condition of the river water before and after filtration, we refer to the report of Mr. Howard Stillman under date of March 6, 1899, on file in the office of the City Clerk.

Dr. T. W. Huntington, formerly of this city, after a thorough examination and careful study of the question of the Sacramento River water as a supply for the city, in a paper read before the Critic Club of this city, on June 19, 1898, said: "In theory and in practice, by experiment and experience, the soundness of the doctrine of artificial water purification seems to be established beyond peradventure. It is needless to discuss the advantage of purified water for mechanical arts and manufacturing purposes. Its absolute faultlessness in this relation is self-evident, and that through the agency of efficient filtration the river source may be rendered perfectly safe, so far as the organic matter and specific infection is concerned, that chemically its standard is almost perfect and that the objections to this source must be laid upon sentimental grounds."

After the most exhaustive tests and experiments, Louisville, Kentucky, has adopted a plan of mechanical filtration, together with a system of sedimentation for the purification of the water of the Ohio River for the use of the city. The Ohio River at times is said to be very turbid, besides being quite filthy, for the reason that many cities and towns situated on the river above Louisville, sewer directly into the stream; yet the filtered water shows a condition of purity not exceeded by water supplies of other cities.

SEDIMENTATION.

The experience of cities similarly situated to Sacramento shows that water as muddy as that of the Sacramento River should be settled before it is filtered. By first settling the water the heavier particles are gotten out of the way; the filters are thus relieved; less filtering surface is required; the cost of operation reduced, and better results obtained.

Sacramento River water is quite easily filtered, and so far as the removal of bacteria is concerned, better results are secured than with water carrying less suspended matter.

The tests made here of mechanical filtration during the months of February and March, 1899, showed that when very muddy water was brought directly to the filter a much larger quantity of alum was necessary to obtain a bright and sparkling effluent than when the water was first allowed one and one half hours to settle. When the water at its worst stage was filtered without sedimentation, one and one fourth grains of alum to a gallon of raw water was necessary, while after sedimentation the amount required was much less, at times only one-eighth of a grain to a gallon of raw water, to obtain the same results.

USE OF ALUM.

The use of a coagulant is mandatory in the filtration of the water of the Sacramento. Coagulants not only clarify, but purify waters. The quantity of alum that can safely be employed as a coagulant, and its action, being fully set forth in the report of the Filtration Commission of Pittsburg, we beg to quote therefrom:

"The quantity of sulphate of alumina (alum) that can be used is dependent upon the amount of lime in the raw water. When sulphate of alumina is added to water, it is decomposed, with the formation of alumina, which forms a flocculent precipitate, upon which its purifying action depends,and sulphuric acid which combines with the calcium carbonate or lime present in the raw water. There should always be an excess of lime in the water. If, however, for any reason there is not, there is nothing to combine with the sulphuric acid, and decomposition of the sulphate of alumina is not complete, and a portion of it goes undecomposed into the effluent. The effluent then has an acid reaction, and is unfit for domestic water supply. When distributed through iron pipes, it attacks the iron, rusting the pipes and giving rise to all the disagreeable consequences of an iron-containing water. The amount of lime in the water at any time available to combine with the sulphuric acid can be determined by a very simple chemical operation, and has been so determined at frequent intervals during the course of our experiments. The amount of sulphate of alumina corresponding to a given quantity of lime can be readily and accurately calculated, but it is not regarded safe to use as much sulphate of alumina as corresponds to the lime. The quantity of sulphate of alumina used is not susceptible to exact control, but fluctuates somewhat, and if the exact theoretical quantity should be employed during twenty-four hours, there would surely be an excess during some portion of that time, from which bad results would be experienced. It is therefore considered only prudent to use three-fourths as much sulphate of alumina as corresponds to the lime in the water."

Thus it will be seen that alum can safely be used as a coagulant in connection with mechanical filtration of Sacramento River water, up to an amount that will correspond to three-fourths of the lime contained in the raw water, as this quantity will be decomposed by combining with the lime, and be precipitated as a gelatinous mass upon the surface of the sandbed, there to restrain all organic matter and other impurities in the water. When the filter becomes clogged, cleansing of the sandbed will be necessary, when the precipitate and all sedimentary matter may be washed away into the sewer.

LOCATION OF THE FILTER PLANT.

The property owned by the city, known as the "Old Water Works" and where the Police Station, Court and Jail are now located, which property adjoins the city's present Water Works, shows a ground space sufficient in size, by the purchase of an additional strip of land to the north, 28.52 feet wide by 125.7 feet long, upon which could be erected a gravity filter plant and settling basin of ample capacity to furnish filtered water to the amount of 12,000,000 gallons in twenty-four hours, or about twice the quantity of water now used by the city.

The present pumping station would not be disturbed, but the old Water Works building would have to be torn down and removed, necessitating the providing of other and more suitable quarters for the Police Station, Court and Jail.

GENERAL PLAN.

The plans for the filter plant herewith submitted were kindly furnished by the O. H. Jewell Filter Company of Chicago, without cost, and at the special request of your committee, who acknowledge that they were the recipients of much valuable information about the general plan of constrution, cost of installing, cost of operation, maintenance, etc., of the filter plant.

It will be seen that the plans submitted were especially designed to fit in, as it were, with the present city Water Works, and become a part thereof; and if adopted and installed, would provide a complete pumping, filtering and distributing plant, capable of supplying clear, pure and soft water, in quantities sufficient not only for the city's present needs, but calculated to take care of a large future increased demand.

Filters known as the "gravity type" are made in what is called "units." That is, each filter is complete within itself. The plans submitted show ten of these "units," grouped and connected and combined.

will have a filtering capacity of 12,000,000 gallons in twenty-four hours. Each unit will be twenty-four feet in diameter, located in a building of suitable size, and will be placed about ten feet above sidewalk level. Under the filters will be a clear water reservoir, made of concrete, with a capacity of nearly a million gallons. This clear water reservoir will be constructed in a system of canals, so that no water can remain still and become dead or flat. From this clear water reservoir the present city pumps will draw water, in place of from the river, as now. On the west side of the filter house will be placed two settling basins. These tanks or basins will be constructed of steel, rectangular in form, and will be eight feet deep. They will contain about 500,000 gallons of raw water, and will allow an hour and a quarter for chemical reaction and subsidence before the water reaches the filter, when filtering at the rate of 10,000,000 gallons in twenty-four hours.

The present city pumps will not be disconnected from the present suction pipe, but a gate will be placed in the suction pipe so that in case the low service pump serving the filter should for any reason become disabled one of the city pumps now in use could be started and no delay suffered.

The entire system will be connected in such a way as to provide a double system, thereby reducing the chance for interruption through accident or otherwise to the minimum. The clear water reservoir, holding, as it will, nearly a million gallons, gives a reserve sufficient in quantity to provide against a lack of water in case of severe conflagration.

The plant being located at one central point, the City Engineer would have the entire plant under his supervision and control.

The raw river water will be pumped directly into the settling basins. For this purpose a low service pump, one of 10,000,000 gallon capacity, will be required. This pump should be operated by electricity, but to guard against accident provision should be made to operate it by steam also.

The water in the settling basins will, through gravity, find its way to the filter, and after purification, pass on and into the clear water reservoir below, and from there be pumped into the city mains.

CONSTRUCTION.

The filter tanks will be constructed of the best steel. The entire plant will be automatic, requiring no special skill to operate it. Any intelligent laborer can soon learn to operate and care for any part of the filter plant. The filter beds, which will be four feet thick, will be composed of crushed white quartz or silica sand uniformly sized. The filters are arranged so that the filter bed can be thoroughly washed and made as good as new. It requires about thirty minutes to wash a twenty-four foot filter bed, which is done by forcing pure clear water through the reverse way, thus removing from the filter bed all impurities and sedimentary matter, and carrying it off into the sewer. Each filter is fitted with a system of rakes, or agitators, which penetrate into the sand bed, and being forced to revolve, break up the bed, enabling thereby the thorough washing of every part. The sand is not wasted in washing to any extent, the overflow being constructed in such a way that only the impurities in the water pass over, and the sand settles back to its bed.

The clear water reservoir will be enclosed so that the filtered water will not in any way be subjected to atmospheric or other contamination while passing from the filter to the city mains.

The movable or working parts of the filter will not be in operation for more than half an hour each day, and being well constructed, and there being no great strain on the parts when in action, there will be little breakage or repairs.

The filter being in "units," should one of them at any time get out of order, the others will in no way be affected or interfered with; therefore, under no circumstances can there be a shortage of supply on this account.

DOUBLE PUMPING.

The low service pump will handle the muddy water from the river, and deliver it into the settling basins, while the high pressure pumps will take the clear filtered water from the reservoir and force it into the city mains. The wear and tear to the high pressure pumps will be reduced to the minimum, by reason of having to handle only clear water, and their efficiency will be increased, as they practically will have no suction left, and the mains will be free from mud or sediment, consequently there will be less friction.

At the lowest stage of the river the low service pumps will have to operate against a head of about thirty feet. The expenses of raising the water to this hight, however, is not all chargeable to the filter plant. The settling tanks are eleven feet above the level of the sidewalk, and allowing three feet for friction in the pipes the cost of raising the water fourteen feet would be the proper charge against the filter plant. Assuming that 10,000,000 gallons of water are pumped daily, the cost of raising water fourteen feet, with coal costing $6 per ton, is estimated at $1.40 per million gallons.

CITY WATER WORKS.

The present city Water Works will not be disturbed by the installation of the filter plant, but the efficiency of the works should be augmented by the purchase of a 10,000,000 gallon high service triple expansion pump, and by the increase of boiler capacity.

By the installation of a filter plant on the lines of the plans herewith submitted, and by the purchase and installation of a new pump and additional boilers, the city would be possessed of Water Works unsurpassed in point of completeness and efficiency by that of any other city.

MAINTENANCE

With machinery handling 10,000,000 gallons of water in twenty-four hours, the estimate for raising 1,000,000 gallons fourteen feet, we think, is liberal, and with electricity the cost should be less.

It is calculated that sixty-five pounds of alum will be sufficient, on an average, to cause the perfect chemical reaction of 1,000,000 gallons of raw water.

As it will require constant and careful attendance to properly care for and operate the filter plant, the services of three intelligent laborers will be required.

The cost of maintaining the filter plant is therefore made up of the following items, and the estimates are on the basis of 1,000,000 gallons of filtered water:

Pumping 10,000,000 gallons of water fourteen feet high, with coal at $6 per ton	$1 40
Fuel for pumping clear water to wash filter beds	25
Coagulant, one-half grain of alumina per gallon of raw water, at 2¼c per lb	1 45
Three attendants, eight-hour shifts, at $2 50 per day	75
Repairs, waste and lubricants	25
Cost of filtered water for washing filter beds..	15
Total cost of filtering 1,000,000 gallons....	$4 25

Per 1,000,000 Gallons.

The life of the mechanical parts of the filter should be estimated and the cost of replacing same calculated, as a part of the maintenance. However, as any estimates we might make to cover the cost of renewal, would not appear in the general running expense account of the filter plant, we make no estimates, but refer to this matter that it may be taken into account when making comparison with any other water proposition that may be considered by the General Committee.

The item of interest in the valuation of the plant should also be calculated and be taken into consideration for the same purpose.

COST.

The representative of the O. H. Jewell Filter Co. has furnished your committee with the following, giving the estimate of cost of the filter plant: "The question of cost for a filter plant of sufficient capacity to furnish bright, sparkling and pure water, and according to the plans submitted, which represents a plant of 12,000,000 gallons in twenty-four hours, is one that can be given, based only upon the cost of labor and material at the time such estimates are made, and must necessarily be subject to market changes. The estimated cost of this plant, made upon market values at the present time, which are at least 50 per cent higher than one year ago, and made by competent engineers and builders, is given herewith. These estimates are liberal and can doubtless be reduced when subject to actual figures and bids.

"The filter house will be 66 feet wide by 189 feet long, as shown by drawings 5454, 5455, 5456 and 5457. In connection, and a part of the filter house, is built the clear-water reservoir, all according to the plans and specifications submitted, including all foundations, settling tanks of 500,000 gallon capacity, and including all piping and valves; one 10,000,000 gallon low service pump (Worthington preferred), ten steel tank filters, 24 feet in diameter, special construction for this work, including all labor and material, and connected complete with pure water ready for the mains, will cost (estimated) $245,000.

"If cypress tanks are used for filters, the cost will be reduced $10,000. In other words, if cypress tanks are used instead of steel, the plant will cost complete (estimated) $235,000.

"The present plans and specifications are prepared for a building of the first class; no doubt a cheaper building could be constructed, thereby reducing the cost; for instance a slate roof is specified, while no doubt iron would answer as well.

"In making estimates on building and filter plant it is figured that the material contained in the old Water Works building or Police Station will be ample to pay for clearing that building off the land."

GUARANTEES.

The Filter Company will guarantee that the filter plant will furnish the quantity of clear water specified, and that the cost of operation will be within the limits of estimates: and that the water furnished will be clear, bright and sparkling and show a bacterial reduction of 97 per cent, and will relieve the city of any and all responsibility if the results are not obtained.

SUMMARY.

Reducing the foregoing report to a summary, we find as follows:

First—That the Sacramento River water in its natural condition is chemically and bacteriologically perfect, an ideal water for domestic uses and manufacturing purposes, safe and wholesome.

Second—That the quantity and continuity of flow are beyond question.

Third—That mechanical filtration is better adapted to the conditions existing on the Sacramento River than sedimentation and sand filtration, less expensive as to first cost, less difficult to operate, and more readily and cheaply enlarged, if an increased supply of water should be required.

Fourth—That the source of water in the Sacramento is open, certain, direct and subject to inspection at all times; that the city supplied with water from this source would be free from any entanglement, legal or otherwise, and not in conflict with any other interests, public or private.

Fifth—That alum as a coagulant is harmless when used in proper proportions, and when so used, the effluent is not in the slightest degree impregnated with it.

Sixth—That the Filter Company will be prepared to make guarantees to the city that the filter, when properly installed, will work up to the estimated capacity, and render the water of the Sacramento River clear, bright and sparkling and bacteriologically safe, and that the cost of operating will be within the estimates

Seventh—That with the filter plant in operation, the city will be better protected in case of severe conflagrations than it is at present, if for no other reason that that the mains will be free from mud or sedimentary deposit.

Eighth—That the present pumping system will not be disturbed by the installation of the filter plant, but will be utilized just as it is. There would be no changing of mains, and the entire system would be located at one common point

Ninth—That the installation of a filter plant under such guarantees as the manufacturers are willing to give, on grounds where the old Water Works building now stands, would be a safe practical and economical solution of the problem of a clear and pure water supply for the City of Sacramento. Respectfully submitted,

THOS. B. HALL,
WM. J. HASSETT.
TOM SCOTT.
Committee.

Specifications for a Filter House and Clear Water Basin and Foundation for Settling Tank for Sacramento, California.

The filter house, with clear water basin underneath, and settling tank will be located on the ground now occupied by the City Jail and adjoining the present pumping station. It will be necessary to buy, in addition to the ground now owned by the city, a small strip of land to the north, 28.52 feet wide by 125.7 feet long, that is the ground between the pipe shop and the fence. The filter house with settling tank will thus occupy a space of 124 feet east to west and 189 feet north to south. The filter house, with clear water basin underneath, will have an outside measurement of 66 feet wide by 189 feet long; it will be constructed substantially as shown on drawings No. 5454, 5455, 5456 and 5457. The elevation of the floor of the filter house is taken at the elevation of sidewalk in front of the present pumping station.

The floor of the clear water basin will be 16 feet below sidewalk level and the floor of the pump room will be 13 feet below level of sidewalk. After the necessary excavation is made, it will have to be determined whether piling is required or whether the sub-soil has enough resistance to carry the weight of the foundations, which will approximately be 1¾ ton per one square foot. The plans have been made with the supposition that the soil will have resistance enough for the above load, which will most likely prove to be the case.

The foundation walls shall be of rubble masonry laid in Louisville cement mortar, or cement of another brand but equally as good; the mortar to consist of one part of tested cement and two parts of sharp sand. The stones used must be of good size, of good quality and of suitable shape to make a well bonded wall; and special care must be taken to have all joints well filled with mortar. All walls shall have a footing of broad flat stones or of concrete.

The bottom of the clear water basin and the floor of the pump house shall consist of concrete 12 inches thick. Wherever concrete is used, same shall consist of:

Four parts by measure of broken stones, three of sand and one of Portland cement. The stones must not exceed two inches in dimensions and the sand must be sharp and thoroughly clean. All must be mixed dry; use very little water, leaving it so that it merely looks damp: ram the concrete thoroughly with heavy rammers.

All foundation walls, the bottom of clear water basin and the floor of the pump room, that is to say, all sides exposed to the clear water basin and pump room, must be faced off smoothly with a coating of cement mortar one inch thick. The four foundation walls forming the outside of the building are carried up to level of sidewalk. The wall separating the clear water basin from the pump room and the walls supporting the filters are carried up to twelve inches below level of sidewalk, with the exception of that part of the filter foundation walls directly under the filter tanks, which are built up to an elevation of two feet and eight inches above level of the sidewalk.

The foundation walls for the filters, as seen from the plans, are alternately connected with one of the main side walls and leaving an open space of four feet and six inches between it and the opposite main side wall, thus producing a zigzag circulation of the water in the clear water basin and avoiding any dead corners and stagnant water pockets.

The foundation walls for the settling tanks are connected with the west wall of the clear water basin, as shown on drawing 5456, with arched openings for the passage of the main sewer pipe. The top of these foundation walls is two feet and two inches above level of sidewalk. The settling tank is supported by ten-inch I beams, weighing twenty-five pounds per foot, and spaced off as shown on plans 5455 and 5456. This will bring the bottom of the settling tank three feet above level of sidewalk.

The filter tanks rest on twelve-inch I beams, weighing thirty-one and a half pounds per foot, and spaced off as shown on plan 5455.

The clear water basin, with the exception of those parts located directly under the filter tanks, is covered with a two-inch matched pine floor supported by two-inch by ten-inch joists, eighteen inches center to center.

The pump room is partially floored over on a level with the floor of the filter house, as shown on plans Nos. 5454 and 5456. This floor consists of a passageway through the center, a passageway along the south and west side of the pump room and around the alum tanks on the east side of the pump room; the remaining portions are left open. This floor has to be supported with suitable posts and brackets along the walls. A stairway leads down to the pump floor and another stairway runs up to the operating platform between the filter tanks. This operating platform is supported by brackets riveted to the filter shells and such intermediate posts as may be required. A suitable iron railing runs along the parts of the filter tanks adjoining the platform, along the stairways and all exposed parts of platform and gallery in pump room. Foundations will have to be put in the pump room for two low service pumps—dimensions of same cannot be specified until the style of pump is selected.

In the southeast corner of the clear water basin is placed a suction well to accommodate the thirty-six-inch main suction pipe and the twelve-inch suction pipe for the wash pump.

BUILDING WALLS.

The building walls from the top of the foundation walls up to the roof will be of hard brick laid in common mortar. The walls will be seventeen inches thick, with inside and outside pilasters projecting four inches.

WINDOWS.

The windows shall have weight balanced sashes, provided with sash locks. All sashes are of first quality white pine, one and seven-eighth inches thick, glazed with No. 1 double thick American glass.

DOORS.

There will be one single door and one double door of good quality pine or poplar and provided with lock and suitable bolts.

ROOF.

The roof is an iron truss roof constructed as shown on drawing No. 5456. The trusses weigh, approximately, 3000 pounds apiece; the purlins are Z bars weighing eighty-two pounds per foot. The roof is boarded with one and one-fourth inch first quality pine, dressed on one side, and covered with slate. The ventilator has swinging, center hung sashes that can be operated with cords from the filter platform.

PAINTING.

All interior woodwork, windows and doors to be painted with two coats of lead and oil, the roof trusses with two coats of mineral paint.

Where anything is omitted by these specifications, reference will be made to the drawings, and vice versa.

It is understood that all material used for this construction shall be of the first quality and the labor done in a good, faithful, workmanlike manner. It is further understood that everything relating to this work will be furnished by the contractor, although they may not be specifically stated by these specifications and drawings.

Final Report of Committee on Sacramento River.

To the Citizens' Water Committee, Sacramento—Gentlemen: Your committee appointed to investigate the Sacramento River water as a source of supply for the City of Sacramento beg leave to make the following supplementary report:

Since submitting for your consideration our report, dated March 5, 1900, we have continued our investigations, and some time ago reached the conclusion that to erect a filtration plant upon the site recommended in that report, at an estimated cost of $245,000, would be unwise for the following reasons:

First—To successfully and economically handle the waters of the Sacramento River by filtration will require the employment of large settling basins in order that the raw water may have at least three hours' subsidence before passing to the filters; and the ground space necessary for this is not available at the site of the present Water Works.

Second—If the ground space were obtainable at the present site, sufficient to build thereon settling basins, filter house, clear water reservoir, etc., the plant would not have a greater capacity than would meet present requirements, and could not be enlarged to meet future needs, which will necessarily increase from year to year; hence to erect a pumping and purification plant to cost, including new pumping engines, boilers and auxiliaries, say $300,000 to $325,000, with no possible chance for enlargement, would be a foolish thing to do.

Third—The present location of the Water Works being within the city limits, near and adjoining large buildings, and close to a network of tracks over which trains are constantly moving, is undesirable, by reason of the ever present danger of destruction of the works by fire, a hazard which the city should by all means avoid in selecting a new site for a plant, whose preservation and uninterrupted operations are of such vital importance to the lives and property of its citizens.

Fourth—Municipal Water Works should be located at a point where the supply is ample, and the danger from contamination reduced to the minimum; hence the advisability of abandoning the present location for one possessing to a greater degree these advantages, and offering also opportunity for enlargement of the plant to meet any increased demands for water in the future.

Fifth—The abandonment of the old Water Works cannot be regarded as a serious financial loss, for the reason that the efficiency of the proposed new plant will be so much higher that the value of the old plant will in a few years be absorbed by the greater economy in the operations of the new plant. Besides, when the old works are vacated.

the boilers, oil tanks, feed pumps and other auxiliary machinery can, no doubt, be disposed of at a good price to some manufacturing concern desiring to locate here, who will also buy or lease the buildings.

The pumping machinery in our present Water Works, aside from the Allis Vertical Compound, which is of small capacity, is of little the Stevens pump having been condemned years ago, while the "Holly" has outlived its usefulness, and the boilers in use are too small for the economical operation of a pumping plant of this size.

LOCATION.

After weighing all these considerations, your committee concludes that a new pumping and filtration plant is absolutely necessary, and has selected, as being the most desirable place to locate the works, a piece of land which formerly belonged to the city, but is now owned by the Southern Pacific Company, same being situated immediately north of what is known as Slater's Addition, and within the levee and railroad embankment. Sufficient ground space can be obtained here upon which to erect an ideal pumping and purification plant, having a capacity sufficient for the city's immediate needs, with ample and additional room for enlarging the plant to meet any future requirements.

CONSULTING ENGINEER.

In order that your committee might pursue its work and be enabled to make a full and comprehensive report of its investigations, it asked and obtained permission from the General Committee to employ a competent engineer to prepare plans and specifications for a complete pumping and filtration plant to be located upon the site selected. Accordingly, we secured the services of Mr. Walter Wagner of Chicago, who has the reputation of being one of the most competent engineers in this line of work. Mr. Wagner came to Sacramento and remained several days, and during the time conferred freely with your committee and Chief Engineer Henry C. Wolf, and made close observations of the conditions existing here, and the requirements to be met. Surveys showing the area and giving the various elevations of the ground at the proposed site were made by our City Engineer and furnished Mr. Wagner. Borings were also made in the ground to determine its character.

Your committee demanded of Mr. Wagner his best thought and consideration in the matter of preparing plans and specifications for the proposed new pumping and filtration plant; and how well he has succeeded can be seen by a careful study of his plans and report, which we herewith submit as a part of our report.

PLANS FOR PUMPING AND FILTRATION PLANT.

Your committee has carefully studied the plans, and has no hesitation in saying that with slight modifications they are admirably adapted to our requirements; and if installed at the new site selected will give this city a pumping station and purification plant not excelled in points of completeness and efficiency by that of any other city in America.

LOW SERVICE PUMPS.

To economically pump the water from the river to the settling tanks during the low stages of the river, which period, according to Sergeant Barwick's report, averages about five months in the year, a low service pump other than a centrifugal will be required, for the reason that the lift, including the friction head in the pipes, exceeds the economical limit of the centrifugal pump. For this purpose Mr. Wagner has recommended a cross compound horizontal pump of 10,000,000 gallons capacity. In view of the fact that the water in the river is more or less muddy the year round, your committee is not favorable to a cross compound horizontal pump, but instead would recommend a vertical compound, notwithstanding the latter will cost some 25 per cent more, believing that the vertical compound pump will give a higher efficiency and prove more economical in the long run. The duty of this pump should be 90,000,000 foot pounds per 1000 pounds of dry steam.

CENTRIFUGAL PUMP.

There will also be installed, to handle the water direct from the river, a fifteen-inch centrifugal pump having a capacity, when working against a thirty-five-foot head, somewhat in excess of 10,000,000 gallons. This pump will be operated by a 150 horse power electric motor.

Either the vertical pumping engine operated by steam, or the centrifugal run by electricity, will handle an abundance of water for present needs, with one pump always in reserve; and each pump being operated by a different motive power, insures continuous and uninterrupted service in case of accident to either pump or power in use.

HIGH SERVICE PUMPS.

For pumping direct into the city mains, it is intended for the present to install two vertical triple expansion pumping engines, each of 10,000,000 gallons capacity, and with a duty of 135,000,000 foot pounds per 1000 pounds of dry steam.

PUMP FOUNDATIONS.

In the low service pump room, foundations will be provided for two 10,000,000 gallon vertical compound pumps and two 10,000,000 gallon centrifugal pumps; also for two 150 horse power motors; while in the high service pump room, foundations will be provided for two 10,000,000 gallon and two 20,000,000 gallon high service triple expansion engines.

DOUBLE PUMPING MACHINERY.

The reason for providing foundations for two pumps of 20,000,000 gallons capacity is that whenever it becomes necessary to increase the capacity of the station, no pumping engine of less than 20,000,000 gallons capacity should be put in. With two 10,000,000 gallon pumps, 10,000,000 gallons of water can be supplied, and leave one pump in reserve; and by adding one 20,000,000 gallon pump, 20,000,000 gallons can be supplied by running either the two 10,000,000 gallon pumps, or the 20,000,000 gallon pump. Again, by placing in position whenever necessary a second 20,000,000 gallon pump, 30,000,000 gallons of water can be supplied by running one of the 10,000,000 and one of the 20,000,000 gallon pumps, always keeping in reserve a duplicate set of pumping machinery.

PER CAPITA.

Thirty million gallons of water is sufficient for a population of 150,000, when figured on the basis of 200 gallons per capita, which is regarded as an extravagant quantity.

CHAIN BLOCK HOIST.

The high service pump room is built in a very substantial manner with a strongly trussed roof capable of sustaining a heavy weight; and in this building will be constructed suspended tracks with moving chain block hoists, for the easy handling of the large cylinders and other parts of the pumping engines.

CAPACITY OF BUILDINGS.

Both the low and high service pump rooms are ample in size for placing therein a double set of pumping machinery capable of handling 30,000,000 gallons of water. Likewise the boiler room is large enough to accommodate the number of boilers necessary for furnishing the power. The filter room, clear water reservoir, and additional settling tanks can be increased correspondingly with the demands for water, at comparatively small cost.

BOILERS.

The plans provide for the installation of four 150-horse power water tube boilers, each having a heating surface of 1500 square feet, with a working pressure of 175 pounds. Fire need be under only two of these boilers at a time to furnish power to operate the pumping engines first installed, leaving the other battery of boilers in reserve.

FUEL.

California crude oil should be used for fuel, and provision has been made for two steel tanks holding 15,000 gallons each, complete with all pipe connections, steam coils and pumps, necessary to use oil as fuel.

ELECTRIC POWER.

Electric power to operate the centrifugal pumps should be obtained from some one of the electric power companies of this city, who should be required to provide a separate and double circuit; and the contract for power should be based on a rate per million for each million gallons of water pumped, or upon a basis of the number of kilowatt hours consumed by the motor.

FILTERS.

The filter house is large enough to hold thirty-two 16-foot filters, each having a capacity of 500,000 gallons in twenty-four hours, or a total of 16,000,000 gallons per day. It is intended to place only twenty-four of these filters in position at first, as this number will be sufficient to purify all the water needed at present.

CLEAR WATER RESERVOIR.

The clear water reservoir built entirely of concrete underneath the filters has a capacity of 1,000,000 gallons. This body of water, always in reserve, overlies the high service pumps, thus avoiding any suction lift by these pumps, thereby saving power and wear and tear, to say nothing of the increased efficiency of the pumps by reason of handling only clear instead of muddy water.

SETTLING TANKS.

Large settling basins which will allow from three to five hours' subsidence of the raw water before passing to the filters is the key to the successful and economical handling of the waters of the Sacramento River.

The plans provide for three iron or steel tanks seventy-five feet in diameter by twenty feet in depth, holding in the aggregate 2,000,000 gallons of water. The raw water is pumped direct from the river into the first settling tank, and is delivered near the bottom. From the top of this tank the water is skimmed, as it were, and passing through pipes to the second tank, enters it near the bottom. Rising in this tank and overflowing again, it enters near the bottom of the third tank in a partially clear condition; but while passing through the pipes from the second to the third tank it is treated with a solution of alum automatically injected in definite proportions. The water which has deposited a large percentage of the suspended matter it originally contained, now, in its coagulated form, overflows into a supply pipe, from whence it is distributed by gravity upon the sand beds of the filters; and passing through the filters, enters the clear water reservoir below, pure, clear and sparkling.

TESTING FILTERS.

At this point it may be well to mention that any company contracting to furnish filters must be required (and no doubt they will be prepared) to guarantee that the filters will not only work up to their estimated capacity, but that all the water passing through the filters into the clear water reservoir shall be clear, sparkling and bacteriologically perfect; these facts to be established by a severe test conducted for a period of at least thirty days.

REMOVAL OF SEDIMENT.

The economical removal of sediment from the settling tanks has been a source of perplexity to your committee, but we believe Mr. Wagner has solved the problem by the introduction of a simple device placed at the bottom of the tanks, making it possible to quickly free each tank of the accumulated sediment, without interfering with the continuous operation of the tanks, and at any stage of the river; thus saving the cost of pumping the water out of the tank preparatory to cleaning it, and all labor and other expenses incidental thereto.

PILING.

The formation of the soil at the proposed site being of a sedimentary character, is incapable of sustaining heavy masonry work; and as a plant of this kind should be built in the most substantial manner, a large amount of piling must necessarily be employed, and in the estimates made a liberal sum has been allowed to cover this item of cost. The cost of piles and driving same, in constructing the crib or jetty, to protect the suction pipes, has also been included in our figures.

PIPING.

About 2700 feet of thirty-six inch steel or iron riveted pipe will be required for the suction from the river to the pumps and connections with the settling tanks, and a line to connect with the city main at Front and I Streets. The cost of this pipe, including laying, also cost of valves and other piping in and about the works, have been carefully figured; and, as will be seen, constitute a considerable item of expense of construction.

LATERAL FOR SOUTHERN PACIFIC COMPANY.

On the line of the thirty-six inch pipe which connects the pumping station with the I Street mains, provision has been made to take out a twelve-inch line of pipe at a point to be hereafter determined, to supply the Southern Pacific Company with water and to afford protection to its property in case of fire. Your committee suggests that on this twelve-inch lateral a water meter be placed to register the amount of water passing through it, and that a low rate per million gallons of water used be made to the Southern Pacific Company.

HIGH CLASS MACHINERY.

We recommend that none but high class pumping engines, boilers and other machinery, including heaters, surface condensers, fuel economizers, oil separators, air and feed pumps, be purchased, to the end that the highest efficiency and greatest economy may be attained in the operation of the plant.

HIGH PRESSURE ON MAINS.

It may not be out of place to here suggest that the Citizens' Water Committee, in its report to the Honorable Board of Trustees, recommend that when this new pumping station is installed an ordinance be passed directing the Chief Engineer to maintain in the city mains a uniform pressure of fifty pounds instead of thirty-five pounds domestic and sixty pounds fire pressure, as is now the case; further, that the hours during which irrigation may be carried on be increased. Your committee is decidedly of the opinion that if a higher pressure were constantly maintained, considerably less water per capita would be used by the citizens than at present, particularly for irrigation. Arguments to sustain this position, we think, are unnecessary here, for it will be apparent to anyone giving the matter any consideration that the adoption of the suggestion would result in great convenience to the citizens, without increasing the operating expenses of the plant.

CHANGES IN POSITION AND ELEVATION OF BUILDINGS.

The ground plans of the proposed plant show the main buildings as facing the south, but after more careful study of the grounds, and taking into consideration possible future requirements, we believe that the main building should face the river. Further, the entire plant should be raised one and one-half feet higher to provide against the contingency of high water. The floor of the boiler room will then be at an elevation of thirty-three and a half feet above datum, or five feet above the highest known water mark.

COST OF PLANT.

Your committee have obtained careful and conservative estimates of the cost of every item entering into the construction and equipment of the plant, and we have no hesitation in saying that we confidently believe the plant can be built and completely equipped ready for operation for the sum of $402,392. Following are our estimates in detail:

BUILDINGS.

Concrete walls, floors, foundations, etc.	$32,500	
Piling, driving and timbers for walls, foundations, etc	12,000	
Brick work in buildings	12,205	
Chimney, brick and concrete work.	3,950	
Lumber, mill and carpenter work..	15,550	
Roofing, galvanized iron, sand and gravel	1,975	
Iron beams, columns, roof trusses, purlins, pipe railings, etc	9,692	
Iron fence around settling tanks...	800	
Wiring for electric lighting, lamps, etc	150	
Painting	850	
Filling in and grading around buildings, railroad side track, etc	4,500—	$94,172

MACHINERY.

Two 10,000,000 gallon vertical triple expansion pumping engines, with 42-inch stroke, including feed and air pumps, set up in place	75,000

One 10,000,000 gallon vertical compound pumping engine, 30-inch stroke, including feed and air pumps set up in place.....	20,000
One 15-inch centrifugal pump, capacity 10,800,000 gallons when working against 35-foot head, with primer and check valve, coupled to dynamo, both on cast iron base, set up in place..	1,150
One 150 horse power electric motor, coupled to centrifugal pump, marble switchboard, all in place	3,750
Two high pressure boiler feed pumps	400
One steam pump for handling waste water	120
One fuel economizer, set up complete with all pipe connections, brick work, etc.........	3,500
Three surface condensers attached to suction pipes set in place..	3,500
One oil separator and hot well.....	300
Gongs, signals, whistles, etc.......	1,000
Water and steam pipes, with coverings and fittings, required for the interconnection of all machinery within the walls of pumping station	5,000
Two 15,000 gallon oil tanks, with steam coil heaters, all pipe connections, stand pipe, oil burners and two steam force pumps, all in place	2,500
Tracks and chain block hoists for handling machinery in engine room	500
Four 150 horse power boilers, set up and complete, with all brick work and connections with chimney	12,500—$129,220

SETTLING TANKS, PIPING, VALVES.

Three settling tanks seventy-five feet diameter by twenty feet deep, in place, and connected with the pumps and filters; 2700 feet 36-inch iron or steel riveted pipe for suction and discharge pipes from river to pumps and settling tanks; line to connect with city main at Front and I Streets, laid in place, together with all other piping, fittings and valves in and about the pumping station	73,800	
Tiling for drain in settling tanks, all in place	200—	$74,000
Superintending, extra labor and other incidentals		5,000

FILTERS.

Twenty-four 16-foot filters, complete and in place, with all pipe connections, shafting, dynamo to operate rakes, ready to deliver clear, pure water........	100,000
Total cost of plant	$402,392

COST OF OPERATION AND MAINTENANCE OF FILTER PLANT.

The cost, exclusive of interest on the first cost of the plant, for supplying the inhabitants of this city with a clear, sparkling water of high bacteriological purity, instead of the highly discolored and ofttimes muddy water of to-day, will be about $3.37 per million gallons consumed, as per following calculations:

Cost of pumping 1,000,000 gallons raw water from the river with the low service pumps working against a yearly average head, including friction in pipes, say thirty feet, using crude oil, which will effect a saving of at least 33 1-3 per cent as against high grade coal at $7 per ton, which will evaporate 8 to 1, will be..................	$0 82

Labor of three attendants, eight hour shifts, at $2.50 per day	75
Sulphate of alumina, average quantity 65 pounds, at 2c per pound	1 30
Raw water for flushing tanks	10
Clear water for washing filters, and extra power required in cleaning	15
Repairs, wear and tear, etc	25
Total	$3 37

Although we have made no allowance in the above calculations, the cost of pumping raw water from the river is not all chargeable to the operations of the filters, for the reason that the high service pumps are entirely relieved of this duty, the filters delivering the clear water to these pumps free of cost.

In making careful inquiry and study necessary to ascertain the class and type of machinery best adapted to modern municipal water works, to the end that the greatest efficiency and economy in operation be obtained, your committee have become thoroughly impressed with the importance of securing the services of a competent mechanical engineer to draw working plans of buildings and prepare specifications for all machinery, piping, etc., in and about the works, and to superintend the installation of same. Therefore, we would suggest that the General Committee, in its report to the Honorable Board of Trustees, recommend (provided, of course, that our report be considered favorably) that a competent mechanical engineer be employed as superintendent of construction and consulting engineer to the City Engineer and Chief Engineer of the Water Works.

SUMMARY.

We summarize the foregoing and our former report as follows:

First—The Sacramento River water in its natural condition is chemically and bacteriologically perfect, an ideal water for domestic uses and manufacturing purposes.

Second—The quantity and continuity of flow are beyond dispute.

Third—The source of the water in the Sacramento River is open, certain and subject to inspection at all times: and the city drawing its supply from this source would be free from any entanglement, legal or otherwise, and not in conflict with any other interests, public or private.

Fourth—Mechanical filtration is better adapted to the conditions existing on the Sacramento River than sedimentation and sand filtration; less expensive as to first cost, less difficult to operate and more readily and cheaply enlarged should an increased supply of water be needed.

Fifth—Alum as a coagulant is harmless when used in proper proportions, not to exceed 75 per cent of the lime contained in the raw water, and when so used the effluent is not in the slightest degree impregnated with it.

Sixth—Filter companies are prepared to guarantee the perfect and successful working of mechanical filters, rendering the waters of the Sacramento River clear and sparkling, and showing a bacterial reduction of 97 or 98 per cent.

Seventh—The City of Sacramento, instead of continuing to supply its inhabitants with raw water with all its impurities, should provide water that is pure, clear and sparkling. To obtain such a supply from whatever source involves the expenditure of a large sum of money; but the end justifies the means, and the sum necessary is small compared with what other cities of equal importance have to expend for similar purposes. The estimated expense, i. e., $3.37 per million gallons, for pumping, filtering and purifying the river water, will be nearly absorbed by the greater economy in operating the new plant, provided our recommendations are carried out, and only high class pumping engines, boilers, exhaust steam heaters, surface condensers and fuel economizers be installed, and that crude oil instead of coal be used as fuel under the boilers.

Eighth—The building and equipping of the proposed pumping and filtration plant, which is an ideal and modern plant in all details, upon the new site selected, would be a wise expenditure of money, a safe, practical and economical solution of the problem of a clear and pure water supply for the City of Sacramento, for all future time. Respectfully submitted,

Sacramento, March 27, 1901.

THOMAS B. HALL,
WM. J. HASSETT,
TOM SCOTT,
Committee on Sacramento River Water.

Report of Walter Wagner, Consulting Engineer, for a New Water Works and Filtration Plant.

CHICAGO, Ill., February 14, 1901.

Committee on Water Purification of the City of Sacramento, Cal.—Gentlemen: The undersigned having been engaged by your honorable body to design a new pumping station combined with a water purification plant, the source of supply to be the Sacramento River, respectuflly reports as follows:

In order to obtain the necessary ground space for an installation designed according to the best present knowledge of the art of filtration, large enough for the present requirements and with facilities for such increase as the future may demand, your honorable body instructed the undersigned to locate the new works on the east bank of the Sacramento River and about 1700 feet north of the north line of I Street. The general features and capacities of the new works are as follows:

Low service pumping machinery will take the water from the river and deliver same into settling tanks. The water level in the settling tanks will be at an elevation of forty feet above datum. Low water in the river being seven feet above datum, these pumps will, therefore, work against a maximum head of thirty-three feet, exclusive of friction in the pipes. From these settling tanks the water flows by gravity to the filters and through the filters. The filtered water is collected in a clear water basin, of capacity of 1,000,000 gallons, situated directly below the filters. The high service or city pumps take the filtered water from the clear water basin and force it into the city mains.

The pumping record of your Chief Engineer, Mr. Wolf, shows a maximum daily pumpage of 8,376,000 gallons pumped in July, 1899, and an extreme pumping for a period of about four hours at the rate of 11,000,000 gallons per twenty-four hours. It is, therefore, safe to assume that a water works plant with a daily capacity of 10,000,000 gallons, with all apparatus in duplicate, will be sufficient for the present needs of the city; but, in order to save money at a future time when an increase becomes necessary, it seems advisable to make the buildings large enough to be able to double the pumping capacity without the necessity of changing or adding to the buildings.

The filter plant is designed for a daily capacity of 12,000,000 gallons that is, 2,000,000 gallons above the pumping capacity, which is necessary, as there are always one or more filters out of service during the process of washing. The filter house is designed to ultimately house thirty-two (32) filter units, with a capacity of 16,000,000 gallons per twenty-four hours; and the settling tanks will be put in large enough to contain three (3) hours' subsidence at the rate of 16,000,000 gallons per day, or 4.8 hours at the rate of 10,000,000 gallons per day.

As there is great advantage in the method of operating to have the settling tanks in three units, and as there is a great saving in first cost to make the settling tanks as large as practically convenient for a given capacity, the writer thinks himself justified in advocating three settling tanks large enough to handle 16,000,000 gallons per day with a three hours' subsidence, which is the limit of time to economically handle the Sacramento River water; and which will give the great advantage of a much longer period of subsidence for many years to come.

The reasons why the writer advocates in his present plans steel settling tanks in lieu of a masonry reservoir are based on local conditions as regards economy of construction and facilities for operation.

As will be seen from the accompanying plans, the building site has an average elevation of seventeen feet above datum; that is, it is fourteen feet lower than the top of the levee; the soil is very unfavorable to sustain heavy masonry work, such as would be required to bring the top of the settling reservoir about nine feet above the levee. A masonry construction would cost at least $20,000 more than the present design, and even then could hardly be considered as absolutely safe against irregular settling, which would mean annoying leaks, contaminating the water in the clear well, thus endangering the entire purification plan.

The life of these steel settling tanks can be safely calculated to be at least fifty (50) years, as their bottoms are entirely covered with cement inside and outside, preventing all abrasion from rust or wear; and their sides, being always accessible, can be kept well painted.

From the accompanying specifications and estimates it will be seen that a very large portion of the cost of construction goes to provide for preliminary sedimentation, but every dollar spent for that part of the work is well invested. It is to-day a well-known fact to every filter engineer that there is no filter which will handle satisfactorily and economically a muddy water such as the Sacramento River water during the rainy season, and that such waters must first undergo a settling process, assisted by coagulation. The writer collected some samples of the river water during his recent visit to your city (taken on January 5, 1901, when the river was nineteen feet above datum and still rising, and the water about as muddy as it ever was or will be). This water contained two thousand (2000) parts per million of matter in suspension, of which sixty (60) per cent had settled after three hours of plain subsidence: and when assisted with a small amount of alum, the water appeared in good shape to be successfully handled by a filter.

APPROXIMATE ESTIMATED COST OF BUILDINGS AND MACHINERY.

Filling in and grading	$4.500	
Filter house, with clear well	35.000	
Pump house	24.000	
Boiler house, office, etc	8.000	
Chimney	5.000	
Pump foundations	5.800	
Boiler foundations	1.800	
Foundation and surrounding walls for settling tanks	17.900	
Storage shed	1.000	
Total for buildings		$103.000
Two 10.000.000 gallon high service pumps	$70.000	
One 10.000.000 gallon low service pump	20.000	
One 10.000.000 gallon centrifugal pump, with engine and electric motor	10.000	
Four 150 horse power water tube boilers, with all necessary feed pumps, pipes and flues, all set up	15.000	
Three settling tanks, with all pipes and valves to connect with pumps and filters	45.000	
Pipes and valves from river to pumps and from pumps to main on I Street	18.000	
Complete filter plant of 12,000.000 gallons capacity	108.000	
Total for machinery		$286.000
Grand total		$389.000

The above estimate can be considered as absolutely safe, and there is no doubt but that the total will be found considerably lower after bids are called for, based on more complete, detailed drawings and specifications.

The cost of filtering 10,000,000 gallons of water per day, if same is done in conjunction with the pumping station and under the supervision of the Chief Engineer of the Water Works, will consist of the following items:

Steam required for low service pump, 1260 pounds per hour, or 24x1260—30,240 pounds per day, equal to 3780 pounds of coal per day at an evaporation of one to eight; or, at $4 a ton for coal, the cost of low service pumping would be $7.56 per day.

There will be needed the attention of one man, or three men per twenty-four hours, with a salary of $2.50 per day, or $7.50 for the three men.

The amount of alum used will average one-half (½) a grain per gallon of water, or 700 pounds for 10,000,000 gallons. The cost of sulphate of alumina laid down at Sacramento will not exceed $1.80 per hundred, or $12.60 for 700 pounds.

The total extra expense for filtering would, therefore, be $27.66 per 10,000,000 gallons, or $2.77 for every million gallons filtered. The repairs on a filter plant are nothing, as has been proven by many years of practical experience; and the above cost of $2.77 will in reality be less, as there will be a saving in the reduced amount of steam used by the high service pumps, which will take water from the clear well without any suction lift and will work against a reduced pressure, as the filtered water will considerably reduce friction in the city mains. There will also be less repair on the very expensive high service engines working with filtered water as compared with the present conditions.

In most places where filters have been put in, practice has proved that it is more economical in the long run to handle filtered water than raw river water, and that a filter plant is not alone a sanitary improvement, but a decided success financially. Respectfully submitted,

WALTER WAGNER.

General Description and Specifications of all Machinery, Piping and Apparatus (exclusive of Building and Foundations) entering into the Construction of the Water Works and Filtration Plant.

(1) INTAKE.

There will be two separate thirty-six inch intakes, provided with foot valves and swinging joints, to raise or lower same according to the stage of the river, similar to those now in use.

(2) LOW SERVICE PUMPS.

There will be installed two low service pumping apparatus, each to be of 10,000,000 gallons capacity, with all piping so arranged as to put in place a third one when required. These pumps will have to work against a head of thirty-three feet at low water and thirteen feet at high water. When the river is high and muddy and the head against which the pump will have to work very low, a centrifugal pump, driven by an economical compound engine or an electric motor, is the most adaptable, but would not be very economical at low water, at which time a horizontal, compound pumping engine would give the best results. It is, therefore, the intention to put in both styles of pump, each capable of working under each condition; one 10,000,000 gallon centrifugal pump with a compound engine and an electric motor, and one 10,000,000 gallon horizontal compound pumping engine, together with all necessary condensing apparatus, air pumps, pipes and valves; the duty of the centrifugal pump to be 75,000,000 foot pounds per 1000 pounds of dry steam and the duty of the horizontal compound pumping engine shall be 90,000,000 foot pounds per 1000 pounds of dry steam.

(3) HIGH SERVICE PUMPS.

There will be installed two vertical triple expansion pumping engines, each of a capacity of 10,000,000 gallons per twenty-four hours and with a duty of 135,000,000 foot pounds per 1000 pounds of dry steam. These pumps will receive the water from the clear well under a slight head; that is, without any suction lift, and deliver same into the city main under a head of 100 pounds for domestic service and a head of 150 pounds for fire service. The piping shall be so arranged that four pumps can ultimately be placed. The exhaust steam from these pumps shall first pass through heaters, from there to surface condensers located in the suction of the pumps; each pump to have its own steam pipe from the boilers and its separate heater condenser and air and feed pumps. All condensed steam shall pass through an oil separator of approved pattern, from where the boiler feed pumps will take their suction. The suction of these pumps will also be connected with the suction from the intake, so as to enable these pumps to take water direct from the river if desired.

(4) BOILER PLANT.

The necessary horse powers required for the above pumps can be figured out as follows:

Low service pumps, maximum head, including friction forty feet, delivery 10,000,000 gallons per twenty-four hours.

Horse power of work done by the water end

$$\frac{10{,}000{,}000 \times 8.3 \times 40}{1440 \times 33{,}000} \quad 70 \text{ H. P.}$$

This pump will require about eighteen (18) pounds of dry steam per horse power per hour.

The high service pump will work against a head of 100 feet for domestic service, which would require per 10,000,000 gallons for twenty-four hours the following number of horse powers at the water end:

$$\frac{10{,}000{,}000 \text{x} 8.3 \text{x} 100}{1440 \text{x} 33{,}000} \quad 175 \text{ H. P.}$$

And as this pump requires about thirteen pounds of steam per horse power an hour, there would be 175x13—2275 pounds of steam—required for every hour. By adding both results we obtain 1260, 2275, 3535 pounds of dry steam per hour to pump at the rate of 10,000,000 gallons per day.

The commercial horse power for boilers is generally accepted to be an evaporation of thirty pounds per hour. According to this, the required boiler horse powers would be

$$\frac{3535}{30} \quad 118 \text{ H. P.}$$

It is, however, a well-known fact that all these guarantees of the pump manufacturers and boilermakers are seldom obtained in practice for any considerable period of time; and as it is, furthermore, bad practice to run a boiler at its utmost capacity (and some steam will also be used for other purposes, as, for instance, the filter agitators, auxiliary air pumps, boiler feed pumps, etc.), it is safe to assume that for general practice there should be two boilers of 150 horse power nominal capacity continuously under fire, with another battery of two as a reserve. There should, therefore, be installed at the present time four (4) water tube boilers, each to have about 1500 square feet of heating service, with a working pressure of 175 pounds, together with a duplicate set of boiler feet pumps.

(5) SETTLING TANKS.

There will be three (3) settling tanks, each to be 75 feet in diameter by twenty feet high, with a combined capacity of 2,000,000 gallons. Two of the tanks will be used for plain subsidence; the third tank for subsidence assisted by coagulation. The piping between the low service pumps and the tanks, between the tanks themselves and between the tanks and the filters shall be so arranged that the tanks can be either run in series or in multiples, and that either tank can be put out of service without interfering with the remaining tanks, all substantially as shown in accompanying plans. The bottom of each tank is provided with a system of drain tile pipes, having holes in their upper sides; all pipes imbedded in concrete to present a smooth, finished surface. These drain pipes are arranged in four independent quarter sections, each section having its own blow off valve at the outside of the tanks, close to the bottom of same. In this manner it will be possible to blow off the accumulated sediment without interfering with the continuous operation of the tanks, and at any stage of the river; thus saving all labor which would be required if the tanks had to be cleansed by emptying same.

(6) FILTER PLANT.

The filter plant is calculated to deliver 12,000,000 gallons of pure, wholesome water each twenty-four hours, at a rate of filtration of 123,000,000 gallons per acre in twenty-four hours, which rate has been demonstrated by practical experience to be perfectly safe for water similar to that of the Sacramento River after being allowed to settle and being treated with a coagulant for fully three hours before passing to the sand bed. The writer was engaged during February and March, 1899, making practical tests concerning the feasibility of filtering this water and these tests have proved conclusively that a method of filtration as below mapped out will guarantee perfect results.

The combined filtering area will be 4241 square feet, divided into twenty-four (24) units of 176.7 square feet each; each unit being, therefore, fifteen feet inside diameter, having a capacity of 500,000 gallons per twenty-four (24) hours. In a plant of this size it would not be good policy to make larger units, even if in that way money could be saved in first cost, as the shutting off of one or more units during the period of washing would unduly reduce the combined delivery of the plant.

The filter tanks will be made of California redwood, the best material known for this purpose.

The filtering material will be four (4) feet deep and will consist of specially mined sand composed almost entirely of silica, with grains uniform in size and shape.

The filters must be equipped with mechanical stirring devices, in order to thoroughly stir up the sand during the process of cleansing and also to allow the top layer alone to be furrowed, in order to break up the top crust, if desired. There will be installed an electric motor for driving these agitating devices.

Each filter will be provided with controlling devices for both the inlet and outlet.

Two (2) tanks, ten feet in diameter by ten feet high, to make the coagulant solution, will be placed where shown on plans; with duplicate acid-proof solution pumps and all necessary connections to feed the coagulant where required.

The filters must be connected with the raw water supply pipe, the pure water wash main and the waste pipe. Everything pertaining to the operation of the filter plant inside of the filter building, with the exception of the operating platform, building and foundations, necessary to put the plant in operation, must be furnished by the filter contractor.

(7) PIPING.

A thirty-six inch steel riveted pipe will connect the intakes with the suctions of all the pumps, as shown on plans; two branches will connect with the clear well in the filter house. All valves must be provided with by-pass valves. The delivery of the high service pumps must be connected with the present main on I Street with a thirty-six inch steel riveted pipe; the approximate length of this main between the pumping station and I Street is about 1700 feet.

General Description and Specifications of Building and Foundations.

It is not the intent of these specifications to enter specifically into all the details of construction, but only to be a guide and explanation for the accompanying plans, to enable contractors to give approximate estimates on the work to be done.

(1) GRADING AND EXCAVATING.

The excavation and grading shall be done in accordance with these plans and the lines and grades which will be furnished. The excavation will consist in grading the surface of the ground where the building and settling tanks will be located, and the excavation of the trenches for the piling and foundations of the building walls. The excavated earth shall be used for the fills. The rest of the material for fills can probably be taken from the river bed. All fills shall be carried up in level layers not exceeding four inches in thickness when applied; every layer to be thoroughly rolled with heavy grooved rollers or rammed well and solidly with heavy rammers and watered more or less if required. A fill will have to be made about fifty (50) feet wide along the south front of the works and around the east side and north side of the boiler house; also the floor under the boiler house, office and repair shop will have to be filled up to grade.

(2) PILING.

The piles must not measure less than nine (9) inches on top; must be straight and clear, of bark and projecting limbs. The piles shall be driven until they sink not more than three-fourths of an inch under each blow from a 1200-pound hammer falling twenty (20) feet. The foundations for the settling tanks are made by laying round timbers, one foot apart, on concrete; the space between the timbers being laid with concrete and filled to about six inches above top of logs.

(3) CONCRETE MASONRY.

The concrete shall be made by mixing cement, sand and clean screened gravel or broken stone, and water. The cement used shall be the best quality Portland cement. The gravel or broken stone used shall have no dimensions greater than two inches. The sand used shall be clean, coarse, sharp and free from foreign matter. The proportions of the cement, sand and gravel or broken stone used in making the concrete shall be by measure, one part of cement, two parts of sand and four parts of gravel or broken stone. The mixing of the concrete shall be in suitable beds or by machinery, in a manner satisfactory to the engineer in charge. After the materials are wet and mixed, the work of placing must proceed rapidly until the whole batch is in place and thoroughly rammed or rolled. The placing of the concrete may be from barrows or buckets, by dumping directly into the forms or through chutes, as the engineer may from time to time determine. The consistency of the mixture shall be such as to insure complete filling of the forms; and, in general, the entire operation of placing, and the consistency of the mixture are to be determined by the engineer as circumstances seem to require. When the filling of any particular section is finished for the time being, the concrete must not be worked upon or walked on until set. All unfinished surfaces, as the work progresses, shall be left so as to insure the best possible junction with that which is to follow, and no work that is set shall be built upon until it is thoroughly cleaned and washed and, when required, plastered with a thin coat of mortar. All surfaces shall be kept moist by sprinkling or otherwise, and shall be shaded from the sun for not less than one week after finishing.

The mortar shall be made by mixing one part by measure of cement to two parts of sand and a suitable quantity of water. Satisfactory moulds, centers and planks or boards for curbing shall be furnished by the contractor. Moulds and centers shall be true in form, smooth and well braced.

Portland cement concrete shall be used for all foundations, etc., with the exception of floors in buildings, bottom of clear well and foundation of settling tanks where Rosendale cement, or some other brand equally as good, may be used.

All exposed surfaces of the concrete masonry of the clear water well shall be plastered with a coat of Portland cement mortar one-half inch thick, well troweled down and floated, so as to leave the entire surface smooth and true to line, said plaster to be applied as soon as possible after the completion of the masonry. The exposed surfaces of all other concrete masonry and concrete floors of the building shall, when completed, be left smooth and true to line and grade.

Any pipe, castings, bolts or anchors belonging to the pump, engine, piping, filters and their auxiliaries, which it may be necessary to place in the masonry as shown on plans, will be furnished to the contractor and shall be set by him.

(4) STONE WORK.

All stone for doors to be granite, and window sills shall be sand stone from approved quarries, sound, of uniform color and texture, and free from discolorations and seams. All visible rock face shall be free from drill holes or tool marks.

(5) BRICK MASONRY.

All walls shall be built of hard bricks; no soft or otherwise defective brick is to be used in any portion of the work. The brick to be carefully culled and the outside and inside faces of the buildings laid of such brick as will produce a good uniform color throughout the work.

All brick work below grade, which is taken at thirty-one feet above city datum, and up to a point twelve inches above grade, shall be laid in cement mortar composed of one part Portland cement, or cement equally as good, and three parts of clean, sharp, coarse, screened sand. Balance of brick work in the building to be laid in mortar composed of one part cement to eight parts of lime mortar composed of lime paste and an approved quantity of clean, sharp sand. All to be kept under cover and well protected from moisture before being used. The lime paste to be used in this mortar shall be slacked not less than two weeks in advance, and the cement is to be added only as the mortar is required for use.

All brick shall be well wet before laying and laid with close joints. Each brick shall be laid in full bed of mortar, and all interstices flushed full of mortar without grouting. The brick work shall be thoroughly bonded; each sixth course to be a heading course of whole brick, extending through the entire thickness of wall. All exposed mortar joints inside to be struck smooth and even and all exterior joints to be jointed with tool. When necessary to bring any joint to the required height, slipped courses shall be formed, as in no case are face joints to be more than one-quarter inch in thickness.

Arches shall be turned over all openings for windows or doors, or where shown on plans, and all centers must be left in place until the brick work has set sufficiently to warrant removal.

All necessary iron wall plates for supporting roof trusses and girders for platform, and iron base plates for posts, shall be furnished and placed by contractor. All plates to be solidly bedded, true and level to line and grade, in Portland cement mortar. The contractor shall also furnish and build in all anchors and clamps of tarred iron necessary to the work. All pudlock holes to be neatly filled with brick of the proper color.

Only skilled masons shall be employed in the work. On completion of the work, the entire exterior of the buildings is to be cleaned down with dilute muriatic acid and water. Care must be taken not to wash mortar joints with acid, and not to let acid run on stone. Point up under sills and wherever required, and leave the work in a finished and complete state in all respects.

(6) ROOF.

The roof of the filter house is supported by steel beam posts, with steel beam girders on which rest the wooden roof joists. These joists carry a ceiling consisting of one inch dressed boarding. The roof itself is a tar and gravel roof. The monitor on the roof shall be constructed of good pine timber, planed on all exposed surfaces.

The roofs over the pump house and boiler house are iron truss roofs, covered with one and one-quarter ($1\frac{1}{4}$) inch tongued and grooved boarding, planed on the under exposed side and covered with No. 26 galvanized iron.

All roofs are provided with monitors, as indicated on plans, with a special skylight placed over the repair shop.

Trusses shall be supported on building walls on heavy cast iron plates and be anchored to walls with bolts and washers built into walls. The contractor shall provide and set all flashings necessary to make the roof water-tight and all galvanized iron gutters and leaders.

(7) FLOORS AND PLATFORMS.

The floor of the filter house rests on steel "I" beams of such dimensions and weights as indicated on plans and wooden joists, covered all over with the exception of the spaces occupied by the filter tanks, with two-inch dressed, tongued and grooved pine flooring.

Operating platform around filters and along the settling tanks to be constructed and framed as indicated on plans; covered with two-inch dressed, tongued and grooved pine flooring and provided with one and one-half (1½) inch wrought iron pipe railing and wooden stairs, all as shown on plans.

A similar platform will be constructed around the high service engines, supported on cast iron posts and steel beams and provided with the necessary stairs and railings.

(8) WINDOWS AND DOORS.

All door frames shall be of first quality pine, of customary construction; the large doors are to be double doors.

Window frames shall be box frames with the exception of the frames in the monitor and the upper half of the windows of pump house and boiler house. The window frames in the monitor to be fitted with swing sash, as shown. All double hung windows to be provided with strong turned iron sash pulleys, sash cords and round weights.

All frames for doors and windows shall be given a heavy coat of paint before being placed in position. The sashes are of first quality white pine, divided into lights as shown on the plans, and glazed with second quality, double thick American glass.

(9) PAINTING.

The contractor shall furnish all material and all labor for the necessary painting and oiling of the building.

All door and window frames, sash and doors in the buildings, the exposed inner surface of roof or ceiling shall be painted with two coats of lead and oil paint of a color satisfactory to the engineer. All iron work is to be given one coat of paint before being set in place and one coat after it is in position; but no cast iron shall be painted until it has been inspected by the engineer.

Report of Committee No. 4.

SACRAMENTO, Cal., September 11, 1900.

To the Citizens' Water Investigation Committee of the City of Sacramento—Gentlemen: Your committee appointed to investigate the proposition of obtaining a supply of water for this city in the delta at the confluence of the Sacramento and American Rivers, respectfully reports as follows:

Guided by the recommendations of competent engineers, tests were made in said locality by boring four wells to a depth of 60, 68, 72 and 106 feet, respectively, and while in each of them a supply of water was found sufficient in quantity, the quality of the water throughout was such as to preclude the possibility of its being entertained for a supply for this city.

We herewith annex report of Mr. Howard Stillman showing the analysis of the water of each well at different depths, also a diagram showing the formation of the soil throughout. All of which being unfavorable and there being no reasonable chance of remedying these unfavorable conditions, we respectfully recommend that said proposition be abandoned.

The total area of lands definitely secured by bond and lease for a period extending to July 1, 1901, would have been sufficient for all reasonable requirements in case this supply should have proven desirable; these lands are, therefore, still available for other purposes in connection with the water proposition should they be found useful or necessary. The total expense of our investigation is as follows:

Cost of bonding and leasing lands.........	$280 00
Cost of boring four wells, including labor and materials	237 20
Cost of analyses	48 00
Total	$565 20

Respectfully submitted,

P. C. DRESCHER (Chairman).
J. H. ARNOLD,
THOS. B. HALL,
HERMAN H. GRAU,

Committee on Supply of Water from Delta near confluence of American and Sacramento Rivers.

Report of Committee on American River.

SACRAMENTO, Cal., June 1, 1900.

Hon. L. Tozer (Chairman) and Members of the Citizens' Water Investigation Committee of the City of Sacramento—Gentemen: The investigation of the feasibility of a supply of water for the City of Sacramento to be taken from the American River and its tributaries, referred to your Committee on American River, having been concluded, the said committee respectfully submits its report as follows:

Two propositions were made and carefully considered, to wit: That of the North Fork Ditch Company and that of Mr. Wm. Muir, each of which will be considered herein separately.

The final proposition of the North Fork Ditch Company with which we are dealing was submitted on the 22d day of May, 1900, after various propositions had, at different times, been made, none of which, however, it was found could be legally entertained by the city, and said last proposition is in the language following:

"The North Fork Ditch Co. hereby agrees to sell and convey by good and sufficient deed of grant to the City of Sacramento, one thousand miners' inches of water from its canal, delivered at its Penstock at or near Orangevale, Sacramento County, for the sum of one hundred and twenty-five thousand dollars ($125,000) gold coin, and further agrees to give said city the right to buy five hundred inches additional water for the further sum of eighty thousand dollars ($80,000), said option to be exercised at any time within twenty (20) years by the annual payment by said city to said Ditch Company of four thousand dollars ($4000) gold coin each year until said city either buys said additional water or notifies said company that it forfeits said option.

"NORTH FORK DITCH CO.

"By C. W. Clarke, President. A. N. Buchanan, Sec.

"SACRAMENTO, June 1, 1900.

"Referring to the option given the City of Sacramento to buy five hundred additional miner's inches of water at the agreed price of eighty thousand dollars, and the payment by the city of four thousand dollars per annum for every year up to the date of the said city's making written declaration either to buy, or forfeiting said right to buy, it was neglected to state that if the city elect to buy said additional water within ten years from date of taking said option, the money paid by the city for the said option, viz.: the four thousand dollars paid each year up to the time of electing to purchase said additional water, shall be applied as part payment on the purchase price as above set forth.

"NORTH FORK DITCH CO.

"By A. N. Buchanan."

Your committee met at frequent intervals whenever the occasion demanded, interviewed at length various competent engineers familiar with the said American River and its tributaries, its various characteristics, stages and conditions during the different seasons, considered carefully the report of Messrs. Cobb and Hesselmeyer, civil engineers, on the feasibility of obtaining a water supply for the City of Sacramento from the North Fork of the American River, also other documentary evidence, and visited in a body and personally inspected the property offered and especially the location of what is known as the "Penstock, or Distributing Reservoir" of said company near Orangevale, also its new dam in the North Fork of said river near Auburn. Furthermore, investigated the subject matter of this report by consulting many other parties thoroughly familiar with the locality through which the ditch of said company runs, and, in fact, gained knowledge from every source of information obtainable; and, after consultation with engineers of recognized ability and standing, find as matter of fact:

That said North Fork Ditch Co. has a valid right to divert and draw from the North Fork of the American River a steady supply of 3000 miner's inches of water.

That at all times during the low stages of the water in the years 1897-8, the lowest known for years, there were 3000 miner's inches of water available at the dam of said company.

That about 1000 miner's inches of said water belonging to said company have been previously contracted for by the residents of Orangevale, Fair Oaks and vicinity.

That said North Fork Ditch Company has about completed the building of a diverting dam in the North Fork of the American River, the masonry of which has been pronounced by competent authority to be good solid work, and will probably stand forever.

That from the diverting dam the water flows through an open ditch or canal located on the west bank of the river and follows approximately the contour of the canyon through which said river flows, a distance of about twenty-five and one-half miles down to the top of a bluff near Orangevale, to a receiving and distributing reservoir.

That from there the water would have to be conveyed in pipes to the City of Sacramento, a distance of approximately twenty miles.

FILTRATION.

That said water when delivered at the distributing reservoir, aforesaid, is not free from impurities and suspended matter, and is objectionable and undesirable; it would, therefore, be necessary to have the water filtered, which can be done at the distributing reservoir, thus preserving the gravity feature of the proposition.

That by proper filtration said water can be rendered clear, pure and acceptable, as has been demonstrated by analysis made by "Purity Committee."

COST.

The probable cost of the aforesaid supply, based upon the best in-

Water right, 1000 miner's inches	$ 125,000
Forty miles, two lines, of 26-inch wrought iron pipe	720,000
Settling ponds, filters, etc.	150,000
Bridge across American River for pipe line	25,000
Ten per cent for contingencies	102,000
First cost	$1,122,000

ANNUAL COST OF SYSTEM.

Interest on bonds at 4 per cent, approximately	$44,880
Sinking fund on basis of forty years	25,000
Estimated cost of care of pipe lines, including deterioration, taking into consideration the gradual decrease in interest	5,000
Operating filter plant, estimated at	17,000
	$91,880

As heretofore reported, under the proposed system 1000 miner's inches continual flow would be equivalent to 15,000,000 gallons per day, which is probably double the average consumption of this city at the present time. Respectfully submitted,

J. H. ARNOLD,
HERMAN H. GRAU,
THOMAS FOX,
P. C. DRESCHER,
Committee on American River Supply.

Report of Committee on Analyses.

SACRAMENTO, August 1, 1901.

To the Citizens' Water Committee: Your sub-committee on purity of proposed supplies beg leave to submit the following report, appending a tabulated report in detail of the analyses of waters submitted to them.

As to the matter of the Sacramento River water, the experience of eastern cities experimenting with and using filtration systems, together with the evidence we have had in our investigations, would justify us in reasoning that the river water could be cleared of from 95 to 99 per cent. of bacteria, and matter in suspension, by the filter system proposed. The river water so modified would be an excellent supply.

The analyses of the test wells showed an excellent water for the city's use, perfectly clear and practically free from bacteria or any evidence of organic matter.

The river water is exceptionally soft for domestic use and manufacturing purposes. The test wells showed a water that was slightly harder, but still one that was well within the limits of what would be rated as good water for domestic or manufacturing purposes.

The degrees of hardness of the different waters analyzed are shown in the appended table referred to, and their relative hardness is referred to the Sacramento River water taken as 1.00.

It will be seen that the relative hardness of the test wells water is considerably below the limit of good water, namely, ten degrees hardness, or approximately 2.00 as compared with Sacramento River water.

Taken as a whole, on the basis of the excellence of the river water, when properly filtered, and the good quality of the test well water, the people of Sacramento are to be congratulated on having two such good sources of water supply.

It is the opinion of this committee that, owing to possible lack of care or ideal conditions at all times in the practical operation of a filter system, that the well supply would prove the more constant or uniform in quality of the two systems proposed.

HOWARD STILLMAN,
ANDREW M. HENDERSON.

Summary of Proceedings.

After organization of the General Committee it was decided that the sub-committees should gather, as far as practicable, all the facts obtainable in reference to the different schemes that would be presented for consideration, and that, in reporting the results of their investigations, no preference should be expressed in favor of any particular plan. It is noteworthy that this provision has been strictly adhered to, as the whole subject-matter was by this means placed in the hands of the General Committee for discussion and final recommendation of such plan as would best serve the wants of our people and the interests of the city. Of the five plans proposed and reported upon it was soon determined that the merits of the East Side Wells and the Sacramento River with filtration were the only sources of supply worthy of serious consideration. In passing upon the merits of the different schemes it is proper to say that the considerations which have been weighed by the committees are substantially as follows:

MOUNTAIN SUPPLY.

The sub-committee has been quite brief in making its report, but the conditions relating to this project do not seem to warrant any other conclusion than what it has reached.

It is true that the thought of obtaining a pure, clear water supply from the heart of the Sierra Nevada Mountains is an ideal one, but it can scarcely be seriously considered from a practical point of view for reasons which the sub-committee has made mention of. If there are those who still think such a project could be successfully consummated, either taken up by Sacramento City alone, or in connection with other large cities of the State, such as Stockton, Oakland or San Francisco, it is proper to state that having given this subject due consideration this committee would consider it impracticable by reason of its great cost and the further reason that with the Spring Valley Water Company established in San Francisco and controlling every known source of supply within its immediate reach and with an ample supply of water for many years to come, it can safely be assumed that it will be impossible, from a financial point of view, for any other company or corporation to gain a foothold upon a profitable basis in said city, and any proposition or discussion tending to show the advisability of carrying out such a plan can only be conceived of by men without experienced judgment or possibly by political demagogues, and certainly no combination of cities outside of San Francisco would feel warranted in undertaking so vast an expenditure for the results to be derived.

Since the committee passed upon the merits of this plan a report and estimate of cost of a mountain supply has been furnished the San Francisco Board of Public Works by City Engineer C. E. Grunsky.

It is inserted here because of its important bearing upon this subject, as showing a conservative estimate of such a plan, by an engineer of well known and recognized ability. A San Francisco paper, commenting upon the report says:

"The report shows that the cost of bringing water from the Sierra Nevada sources for a delivery of 30,000,000 gallons per day in a single pipe line falls as low as 8.53 cents per 1000 gallons, and that if a double line of pipe be used the cost will be 9.63 cents per 1000 gallons.

"When the works are planned with an expansion to 100,000,000 gallons a day as ultimate capacity, the cost of the water delivered by a single pipe line would be 8.49 cents per 1000 gallons, and 10.39 cents per 1000 gallons if delivered in two pipes, each having a capacity of 15,000,000 gallons."

"City Engineer Grunsky states that the following figures are subject to revision and may be used as a basis of what the cost of bringing water from the three sources named may be in the future:"

YUBA RIVER PROJECT.

Canal capacity from North Yuba River, at Alabama Bar, to Oregon House Reservoir, 30,000,000 gallons per day.

Oregon House Reservoir storage capacity, 30,000,000 gallons.

Single pipe, 56 11-100 inch diameter; capacity 30,000,000 gallons per day; via Carquinez Straits and under San Francisco Bay, cost...	$21,605,000 00
Investment per million gallons of daily capacity	720,000 00
Cost of each million gallons delivered	106 00
Double pipe, each 56 11-100 inch diameter; combined capacity, 60,000,000 gallons per day, same route; cost	$34,178,000 00
Investment per million gallons of daily capacity	570,000 00
Cost of each million gallons delivered	81 86

STANISLAUS RIVER PROJECT OR TUOLUMNE RIVER PROJECT.

Canal and tunnel capacities, 100,000,000 gallons per day. All water to be stored.

Single pipe, 48-inch diameter (taken from curve). Capacity 30,000,000 gallons per day, via Livermore Pass; total cost	$18,400.000 00
Investment per million gallons of daily capacity	613,000 00
Cost of each million gallons delivered	84 90
Double pipe, each 36½-inch diameter; capacity 30,000,000 gallons per day, via Livermore Pass; total cost	21,800.000 00

Investment per million gallons of daily capacity	726,000 00
Cost of each million gallons delivered	103 85
Double pipe, each 48-inch diameter; capacity 60,000,000 gallons per day; via Livermore Pass; total cost	29,260,000 00
Investment per million gallons of daily capacity	487,000 00
Cost of each million gallons delivered	69 57
Double pipe, each 36½-inch diameter; total capacity, 30,000,000 gallons; canal and tunnel capacity, 60,000,000 gallons per day; total cost	19,800,000 00
Investment per million gallons of daily capacity	660,000 00
Cost of each million gallons delivered	96 25
Single pipe, 48-inch diameter; capacity 30,000,000 gallons per day; canal and tunnel capacity 60,000,000 gallons; total cost	16,200,000 00
Investment per million gallons of daily capacity	540,000 00
Cost of each million gallons delivered	80 53

From the above it will be seen that $69.57 per million gallons is the lowest estimate made, which is about five times the cost of the committee's estimate for clear water by filtration, two and one-half times the present cost of Croton water to New York City, and practically the same as the notorious Ramapo contract ($70.00), which was attempted to be forced upon New York two years ago.—"The Water Supply of the City of New York," p. 19.

NORTH FORK DITCH.

This project is practical and has its advantages and disadvantages. Its chief advantage is, of course, its gravity feature, and which is sufficient to eliminate the cost of a pumping plant and possibly do away with the use of fire engines in the city, although this has not been made clear. The quality of the water is perhaps as good, but no better, than our present source of supply, and so by its use filtration would become necessary and the cost of same would be materially above the sub-committee's estimate for filtering the Sacramento River water by reason of its remoteness from the city and away from railroad communication. There is more or less danger of interruption by the breaking of the ditch between the dam and the reservoir near Orangevale (about twenty-five miles), but the greatest objection is the enormous first cost for piping and other necessary outlay (about $1,100,000), together with the positive knowledge that the life of the pipe system would not in any event exceed forty years, when it would be necessary to have same renewed.

JUNCTION OF SACRAMENTO AND AMERICAN RIVERS.

This plan has had numerous advocates from time to time, some of whom were prompted to say to this committee that it would only be necessary to excavate cribs near the river to a depth somewhat below the low water stage, where an abundant supply of desirable clear water could be obtained without other expense than pumping. The fallacy of this theory was proven by the work of the sub-committee after considerable unavoidable delay and a moderate expenditure of money. The tests made have demonstrated that no large amount of water can be obtained except from deep wells and whatever amount might be developed would be of the most objectionable character, and, to go a step farther, it may be said that this seems true of all ground waters that have been obtained from any locality within the city limits, and as far north as the American River. It is, therefore, a fairly well-established theory that all sedimentary formations upon which the city is built are more or less impregnated with alkali, or mineral matter in solution, which make water from wells undesirable for domestic use. This, we think, has proven true with the water taken from all wells that have been sunk within the city limits, as it has been by the Southern Pacific Company upon its grounds, and also by others who have sunk wells at different points within the city, especially at the Pioneer Mills, Buffalo Brewery and Sacramento Swimming Baths. It is also in evidence that the Abbott & Henry wells, located near Guthrie Station, were not entirely free from this objectionable feature.

EAST SIDE WELLS.

This scheme has for many years had a large number of ardent advocates who have contended that it was only necessary to go east or southeast from the city, sink wells, attach proper pumping machinery when an abundant supply of pure, clear water could be obtained. This plan would no doubt have had more friends at the beginning of the committee's work had it not been for the unfortunate experience the city had some years ago with a private contractor, wherein the city came near losing its valuable water system for a long time, if not altogether. While it is true that no good ground water, so far as known, has been developed from wells within the city limits, it is equally true that most excellent water has been developed far enough southeast to be entirely away from the sedimentary formation underlying the city of Sacramento. And the well tests made by this committee in January, 1900, have shown conclusively that a large volume of excellent water is available at or near the place chosen for the experiment. It is also known that water of like good quality is found upon the Monte Vista Tract and points farther south, so it is evident that the advocates of this scheme have good grounds for their opinions, and that this plan is the only one comparable with the Sacramento River with filtration.

SACRAMENTO RIVER.

It has been well said by Engineer Hering, "Not a word need be said about the abundant quantity of water in the Sacramento River." And every Sacramentan knows that when freed from sediment the quality of the water is the most desirable of any within our reach. That it can be filtered perfectly at a moderate cost has been clearly demonstrated and shown by the sub-committee's report.

FILTRATION.

In the matter of filtration, the committee has given due consideration to the English, or slow method, but the reports received and considered from other American cities have shown to its satisfaction that mechanical, or rapid, filters are best adapted for treatment of waters as turbid as the Sacramento River, and the estimates have been based upon that type of filters only. In support of this conclusion it is found that the cities of Pittsburg, Pa.; Washington, D. C.; Lawrence, Mass., and Albany, N. Y., where the water is comparatively clear most of the year, have adopted the English, or slow method, while the cities of Cincinnati, Ohio; Louisville, Ky.; Quincy, Ill.; Elmira, N. Y.; Providence, R. I.; Norfolk, Va.; Kansas City, Kan., and other cities and towns of less importance, having either discolored or turbid waters similar to the Sacramento River, have adopted mechanical filters. The decision of the authorities of Louisville is regarded as of special importance in this connection from the fact that the water company there is operated independent of municipal control and conducted strictly upon business methods. Its Chief Engineer, Mr. Chas. Hermany, who has operated the system for many years and conducted a long series of filtering tests under the direction of Mr. George W. Fuller, finally decided that mechanical filters were by far the best suited for waters of the Ohio River—his reasons being that the same results could be obtained at less cost, and the further reason that the machines were always under control and easily handled. The opinions of all engineers with whom this committee have consulted agree that equal results can be obtained with either system and that it becomes a question of economy as to which should be used for the treatment of different kinds of water, and whichever may be adopted for the treatment of the Sacramento River water, the use of alum or some other coagulant would become necessary at all times.

As a further evidence of the merits of mechanical filters for turbid waters, we quote from the recent report of Messrs. Rudolph Hering, George W. Fuller and Allen Hazen, on the "Methods of Purifying the Water Supply of the District of Columbia."

"Within the past few months material improvements in mechanical filters have been developed in connection with several municipal water supplies. These departures from former types of filters, in a measure, are made possible by the expiration of the Hyatt patent. In our endeavor to solve the Washington problem we have devoted ourselves to a careful consideration of the relative merits of these two methods in their most improved forms.

"The question of deciding between the two systems of purification, with the improvements above indicated, is in some respects a difficult one. In character the water for Washington is intermediate between the waters for Pittsburg, where sand filters are best adapted to the conditions, and the water for Cincinnati, where American filters are preferable. If the Potomac waters were more turbid, or turbid for longer periods than the records show, mechanical filters would unquestionably have the preference. If it were less turbid, or if turbid periods were of shorter duration, the advantage would clearly lie with sand filters.

"Our knowledge as to the results that can be obtained by mechanical filters rests more upon the experimental evidence than upon results obtained in practice. Nevertheless, these investigations have been made upon such a scale and with such care as to give the greatest confidence in their results."—"Purification of the Washington Water Supply," p. XV.

CONCLUDING REMARKS.

Your committee having exploited every proposition that has been presented, finds that the city has available two excellent sources of water supply, to wit: The Sacramento River, with filtration, and the East Side Wells, either of which would no doubt be satisfactory if adopted and put in operation. The quality of the water from the two sources being satisfactory (after filtration of river water), the problem becomes a question of relative cost, with a possible lack of quantity in the minds of some from the wells supply. It is a well-known fact that the Sacramento River affords an abundant supply at all times and there is no question but that it will continue to do so for all time to come, while, with the modern methods of filtration it can be made clear, sparkling and free from dangerous bacteria. This fact has been demonstrated by the tests made in this city during the Spring of 1899; besides. tests made at other points furnish abundant proofs.

The quality of water drawn from wells during the tests made in January, 1900, is also satisfactory, though not quite as soft as the river water. The various reports of the sub-committees were, in the month of May, 1901, placed in the hands of Messrs. L. J. Le Conte and Rudolph Hering, civil engineers, for their consideration and recommendation. Their final reports are herewith appended.

Final Report of Rudolph Hering.

Meeting of the Citizens' Water Investigation Committee on May 28, 1901, for the purpose of listening to the report of Mr. Rudolph Hering.

Mr. Hering—Mr. President and gentlemen: When I was here before, a year and a half ago, I looked over your situation, as you remember, wrote you a preliminary report, and suggested to you what I thought should be done to solve the question before you. Since that time you have made certain investigations. Mr. Le Conte, of San Francisco, conducted some experiments that were necessary to reach some conclusions on one of the propositions that you had before you, and he also made a report. Since that time, you have also, through your subcommittees, made reports on different questions before you, on different means of supplying the city with good and wholesome water. As I was coming out here for another purpose, your Chairman asked me to look over this water question once more and give you my present opinion. I was fortunate enough to select a time when Mr. Le Conte was also here, and we have been together now for two weeks, spending some of our time on this vital question.

Mr. Le Conte has informed me more in detail of what had been done than I was cognizant of during my absence, and I have given the matter my best thought, and have tried to assist you in it so far as I was able, before I would leave. I asked Mr. Le Conte to aid me, because I found that I had a great deal to do in the other question and the time was short.

Now, I have gone over the whole question in my mind again, and I will briefly state to you my conclusions, and the way I arrived at them, and then afterwards I will be very glad if you will ask me as many questions as you think will throw more light on the subject, and particularly to have you understand my own way of thinking, and the reasons for telling you what I am going to tell you.

This whole question, in my mind, divides itself into three points: First, the quantity of water that you can get at the different places; secondly, the quality of the water, and, thirdly, the cost of supplying your city with the same. You have, I think, rightly narrowed the whole investigation down to two projects: One is the taking of the Sacramento River water and filtering it, according to the best known methods, before piping it into your city and distributing it to your citizens. The other is tapping an underground stream of water in this neighborhood, which is already filtered water, and pumping it into your distribution system.

Now, to properly compare these projects, they should be compared on those three lines that I have just mentioned—

QUANTITY, QUALITY, COST.

With reference to the quantity, not a word need be said about the abundant quantity of water in the Sacramento River. But the quantity of water to be found in the underground strata is an important matter; and, as we cannot see it running on the surface, like water from springs, or in brooks or rivers, we must have some other means of finding out its quantity, and that is largely by inductive reasoning. We know where this water originally comes from; it all comes from the rainfall.

Now, the rain water either runs off on the surface, or it percolates through the soil and runs off underground. Whatever is not disposed of in those two ways evaporates either directly from the surface of the ground or passes through the plants. There is no other accounting of the rain water. Now, you know what runs off on the ground, because you can see it and measure it. To determine the quantity of underground water you have to apply some reasoning; and it was suggested here that, from geological conditions and from experience in the neighborhood, there was a flow of ground water east of the city.

The only doubtful elements were, "How much is there, and what is its quality?" The first element was the quantity. A rough estimate convinced me, at my former visit, that there would be enough there to warrant a trial, and I so recommended to you. A test was made under some difficulties; nevertheless, what I considered a satisfactory result was reached.

Now, in going a little further and following this question up, it might be well to consider the map of this neighborhood. The geological formation of the ground east of Sacramento, where this water comes from, is favorable towards having a good quantity of water. It comes from the mountains, and there is a very large area on which water may percolate into the ground and run under the surface to a lower plane; and it is very evident from the map and from the gravel strata west of the mountains that a large quantity of water must flow towards the west and southwest.

The tests that you had made only extended about 900 feet across this line of flow, and I might add here that this flow is demonstrated absolutely by the levels of the ground water surface taken at different points. The slope of the water surface causes it to flow.

We have several ground water supplies in our country. There is one in Tacoma; there is a very excellent one in Newton, Massachusetts. The largest ground water supply in the world is in Brooklyn. And in Europe several of the largest cities are supplied entirely by the ground water, such as Dresden, Leipsic and Munich, cities each of over 300,000 people. They get all their water from driven wells or galleries, some twenty feet or more below the surface and from water that flows under the ground instead of on the surface.

Another question was, if there is a flow of water to the west or southwest, where does it go to? If it flows, it must be discharging all the time, and it does not go into the Sacramento River near the city, because it is lower sometimes than the river. We must satisfy ourselves on every feature of this question before we can say, with confidence, what the result will be. From this map which I have before me, I notice swamps near the river, and, by the contour lines, I see that there is plenty of fall and an opportunity for this water to flow down in a southwesterly direction and escape into the lower Sacramento River and other watercourses east of the Sacramento River and north of the San Joaquin River, so that the conditions which are found to exist entirely answer the question as to what becomes of this ground water and where it goes to. The tests were made along a line crossing this underground river, so to speak. Therefore, a portion of this underground river was intercepted by the wells on a line stretching across it about 900 feet, and you got from this distance over 4,000,000 gallons a day.

Now, you have yet four or five times that distance across this underground river before there is any reason to think that the flow will cease. Therefore, there is no question about getting all the water from this ground supply that you will need, for a long time.

IT IS ENTIRELY SAFE

To base an estimate of cost on 10,000,000 gallons of water a day, such as Mr. Le Conte has prepared, and I am confident you can get much more. There is no doubt at all about it, and the beauty of a system of this sort is that you can readily extend it as you need more water. In Winnipeg, Manitoba, I suggested an underground supply on the same lines, and I estimated that a series of wells about a thousand feet across the flowing stream might get enough water. They got all the water they needed within a hundred feet, and they still have nine hundred feet to go for more, if they want to.

So far as the quantity is concerned, I am, therefore, satisfied that we have enough water here for your purpose. The question of quantity, therefore, does not decide the preference between river and wells.

QUALITY—FILTRATION.

The second point which might decide the matter is the quality of the water. The Sacramento River water must be purified, and there are two methods for doing this, which you have investigated—a purification by the rapid, or so-called mechanical, filters, and a purification by the slow, or so-called sand filters. The main difference between the two may be narrowed down to a question of speed. In the slow filters you get water percolating slowly—a column of about ten feet high passing through the filter in a day. In the rapid filters, a column of water 250 to 300 feet high passes through the filter in a day, and this rapidity of filtration enables the filter to be made a great deal smaller. The purification of this water being the object to be accomplished, must, in the rapid filters, be assisted by an artificial film that is formed on top of the filters by some coagulant to strain out the bacteria.

This coagulant is a sine qua non with the rapid filters, and in that way accomplishes the same object as the slow filters without a coagulant in all but very turbid waters. I am pleased to say that both methods are to-day practically on a par for solving the important question of water purification. I have recommended both, and I am ready to recommend either under the circumstances that may exist in any particular locality. Large sand beds are sometimes very expensive, and at other times objectionable where the water contains fine suspended clay which will go through a slow filter, unless you use a coaguiant.

On the relative preference of slow and rapid filtration of the Sacramento River water, you lack information regarding the fine suspended matter. I think a coagulant is necessary at times for the Sacramento River water, even if you want to use the slow filter, and for the rapid filter you must use it all the time. You have made what seems to me an excellent, able report, and you have decided that you prefer mechanical filters to the slow filters. I do not see that there is much difference between the two in your case, so far as the quality of the resulting water is concerned, and, as a rule, there is not much difference in the cost.

When I say there is a little difference in the cost, I mean in the annual cost for such a system, which is the only proper way to estimate the value. The slow filters cost more money at the outset, but they cost less to operate. Therefore, the total annual expenses are sometimes very close, and a decision is very difficult to make for that reason, and sometimes is based on other grounds than that of cost. So I think that your decision to use the mechanical filters may be a proper and a correct one. In any event, there should not be very much difference, so far as the cost and effectiveness is concerned.

Therefore, the quality of the water of the Sacramento River can be made so that it will give every satisfaction that you expect. It is a very soft water, very pleasant to the taste, and when it is deprived of its suspended matter and bacteria I do not think there is much better water to be obtained anywhere.

THE WELL SYSTEM.

Now, with reference to the well system. How is its quality to be determined? You made an analysis of this water during your tests, and I understand it was of very satisfactory quality. The bacteria were, of course, practically absent, but it is a little harder than the water of the river. It is not nearly as hard as the Spring Valley supply in San Francisco, so that the hardness should not be considered an objection to that water.

The question now is, Will that water, when you get your wells in operation, and your machinery pumping continuously year after year, change its quality from what your well tests showed? Will it remain the same?

In order to satisfy one's self on that question, it is necessary to study a little further into the history of the ground water before you take it, and there the geological features come in. The rain water goes down into the ground, mixes with the sub-surface soils and sands, flows on the rock or in its crevices, and finally gets into the bed of ground water which flows toward the river or ocean.

The absence of volcanic rocks and of limestone is a very favorable indication for the quality of this water, of which we can trace the history and which does not flow a great distance below the surface. We are safe in saying that there is nothing by nature near the source of this water that is going to hurt it in the future. At other places where we have similar conditions and where ground water is obtained, the same conclusion was reached, and there has never been an unpleasant surprise where a proper and careful study has been made.

I therefore feel quite confident that the quality of the water will always remain as it is. Its present softness is, in part, a confirmation of that conclusion, because it shows that the territory must be of such geological formation as we see it to be from the surface indications.

There is another feature which relates to the quality of the water, and that pertains to artificial influences. The surface of the earth is cultivated. Human habitations are there and cesspools are dug. Humanity may seriously alter watercourses. A city discharging sewage into a small river may change it very much. The question is, Will such a sewage pollution of this ground water take place? I think that the answer to that question is largely within your own control.

If you see to it that no nuisance-creating establishment of any kind is erected in the direction where this water comes from, no very deep excavations are made into which filthy and foul matter is deposited, you have it in your control. But, in your case, it would take an enormous amount of pollution of that kind to affect the water in the ground to such an extent that you would be able to notice it chemically or bacteriologically by analyzing the water that you would get in the city.

The quantity of water is comparatively great, and its passage through the sand, acting as a filter, is doing precisely what you would do in your mechanical filter or in your slow filter, where the water passes through but a few feet of sand, and precisely what nature is doing through thousands of feet of sand when converting polluted surface water into spring water or ground water.

If you can guard against such an extraordinary and unusual occurrence as a violent pollution of this ground water anywhere towards the east and northeast, where, it is very clear, this water comes from—and there is no doubt at all that you can prevent it—you can rest absolutely sure that the quality of that ground water is going to be as good and perhaps better than most of the artificially purified drinking waters that we have in this country and elsewhere.

In fact, regarding quality, I would say you are safer with the ground water than you are with the filtered water, because nature works according to definite fixed laws, and if you only know them, you can watch and regulate. But a human being, operating a filter, is apt to slip up sometimes, and it is at least as probable that you will get improperly filtered water as polluted ground water, under the particular conditions of your case mentioned above.

I therefore honestly feel, so far as the question of quality is concerned, that there is again no decided preference between the two sources. One element of comparison still remains, and that is

THE COST.

In order to make a proper and fair estimate of the cost of works for the purpose of comparing their value, we must divide the consideration into three parts. Unless we do this, we are apt to mislead ourselves and form a false conclusion. The three parts are these: First, the interest on the capital ,which you invest at the outset. That is an annual expense that you have to pay, and is a fixed charge. Secondly, the operating expenses of your plant.

With the filters, taking the water of the Sacramento River, you have certain expenses which are necessary to clean that water, and then others to pump it into the city. With the ground water system you have certain operating expenses to pump the water and deliver it into the city mains. The water is clear when you take it, and does not need purifying. Now, the comparison of expense should be made in such a manner that the water is delivered in the city in this pure state by both projects under exactly the same pressure.

You have, therefore, to pump it higher if you get ground water, because the pumping station is further away from the center of population than if you take the water from the point where you would erect filters. Now, these conditions should be carefully equated, so that we are entirely fair in the comparison. In estimating the cost of purifying your water, you must take the best experience. The cost of purification is confined, of course, to the river scheme, and does not apply to the other.

We have, therefore, one element of relative uncertainty, although not a large one, in the estimate of cost in the purification scheme. I have gone over your estimates, and I am sorry to say that, in my opinion, the allowance for alum, which would be necessary in this case, is too small. The cost which you would have to pay for filtering this river water by the mechanical filters, as I figure it out from your report, is less than what is warranted by the experience gained in the East, where there has been a good deal of it.

I should certainly be afraid to make an estimate on the figure that you have taken, for I think that you will be obliged to use more alum than a half a grain per gallon. We have had experience in the East with waters which, apparently, are not as turbid as the Sacrament River water, and more than half a grain of alum has been required. Engineers should not under-estimate the cost of their works, and when I say that I believe you should estimate on one grain per gallon for this water, it is because the data are lacking as to the amount of suspended clay in your river water, which determines the amount of alum that must be used.

From conversation, I have heard that there is a great deal of fine clay in this water, which keeps it in a turbid state for quite a while. That is precisely the experience we have with the clay-bearing waters of the Mississippi Valley, and it seems impracticable to get that water clear, unless a coagulant is used all the time. You would very likely have to use more than half a grain per gallon. But the conclusion, as you will see, does not depend on whether you use a half a grain, or a grain, to the gallon. I merely think it my duty to tell you that, to be safe, I should estimate one grain rather than half.

The next item of cost is the depreciation. Take a supply from the mountains brought in a stone conduit delivered into a masonry reservoir, and then into the city; the depreciation on that system is practically nothing. If it is properly built, it would last hundreds of years. A mechanical contrivance—a pumping engine, a boiler or something of that kind—we all know that they have a limited life, after which they are useless. We must get a new boiler, we must get a new engine, we must even get new pipes into the ground, and so on.

Now, a proper method of comparing works of this nature is to allow, annually, a certain sum of money which will not only keep the works in repair, but always in a permanently perfect condition, equal to the stone aqueduct. We make this allowance by placing a sum of money aside every year, sufficient in amount to rebuild the boilers and engines when they become worn out, replace the pipes and all the machinery, put on new roofs and so on, so as to keep the plant always in a perfect condition.

This method of comparing values we have used in all large cities and all large works. It is the same as used by a successful business man in order to determine what is the most economical project to carry out. Now, the depreciation has been estimated to the best of our judgment, Mr. Le Conte kindly helping me in the same, and there has been added, in both cases, a sum of money which, annually set aside, will keep your works permanently in good condition.

THE FINAL RESULT,

Gentlemen, is this: Suppose that you use 6,000,000 gallons of water per day. You will have, for the filter project, an annual cost of $52,000. That includes the pumping of the water into the city mains; and it includes, in addition to the committee's report, an allowance for an extra half grain of alum per gallon. For the 6,000,000 gallons supply from the wells, these items add up, including the pumping of the water to the city, in equal quantity and with equal pressure, to about $37,000 per annum.

You therefore see that the well scheme is very materially cheaper than the filter scheme. Making an estimate on supplying 10,000,000 gallons, the results are as follows, making the same additions that I mentioned before. It is a cost of $83,300, as representing the annual expense for the filter project, and $59,961, say, in round tumbers, $60,000, as the annual expense for the wells project.

Now, gentlemen, the conclusions regarding the preference is, to my mind, self-evident. I have tried to build this whole question up from the foundation, gradually and consistently bring it to its legitimate conclusion, and you have the result clearly in favor of the wells project.

QUESTIONS BY MEMBERS.

The Chairman—Do any of the gentlemen have any questions?

Dr. Henderson—There is one point, Mr. Hering, and that is why you judge that the cross-section there is so much wider. You say that we have experimented with a cross-section of 900 feet. Now what is the ground for judging that that cross-section could be doubled that we might go 1800 feet and obtain a corresponding result?

Mr. Hering—This map is the ground for that opinion.

Dr. Henderson—Yes.

Mr. Hering—Mr. Le Conte calls my attention to the blue print, which shows the number of wells which have actually been sunk down there and where water has been found. But, irrespectively of that the territory is of such a nature that there is a wide expanse of water-bearing gravel lying across this plane sloping from the mountains. There are absolutely no indications, geologically, why there should be any sudden change beyond the 900 feet. The conclusion that you are going to get more water, as you go along, as found in every similar case, is quite safe.

The Chairman—Is there any reason to suppose that the underground water does not flow fifteen or twenty miles or to the Cosumnes River, for instance?

Mr. Hering—Well, it very likely does flow that far. I don't see what reason there would be for it not extending to the Cosumnes River. The configuration of the land is such as to make it highly probable. But you will have to notice that we only have confined the estimates to 10,000,000 gallons, and there is no doubt about that quantity, gentlemen.

Mr. Scott—You say that all this water in the ground comes from the rain water. Where does this artesian water come from that comes up from the pressure?

Mr. Hering—That also comes from the rain, but it comes in a little roundabout way. It comes from rain falling on a higher territory, and it percolates into the ground and goes under some impervious stratum, and then comes up again. If the ground happens to be of a less elevation, where it comes up, than the surface of this ground water reservoir which supplies it, it will flow out of the ground. Water always seeks its own level, and when you have an artesian well, you know that the water comes from a reservoir which is higher than the ground where this stream of water appears. Such a reservoir is nothing more nor less than the reservoir underlying the surface east of the city, which you have been tapping for your wells supply system; only, in the artesian system, the reservoir would be higher up, so that the water, seeking its own level, would come up out of the ground. But in every case the rain or snow supplies the source.

Member of Committee—Mr. Hering, you say that the general contour of the ground, the general formation, determines you in saying that the quantity of water will be large, and almost uniform there?

Mr. Hering—Yes, sir.

Member of Committee—Well, does that also, the general formation, determine your saying that the quality and the quantity will be uniform?

Mr. Hering—Yes, sir; I intended to have it inferred that the quality would be the same throughout this territory, which is the feeding ground for the land to the east of your city. If it were not already proved, it can be determined very easily from existing wells. Of course, the more wells you examine the more you will know about the waters.

Member of Committee—Well, supposing it should be found that the waters vary materially in a short distance, where there would be apparently no good reason, only judging by the general appearance of the country, the contour of the country?

Mr. Hering—The underground flows are like rivers. If the quality of the water varies suddenly in a river, it is due to something getting into it, some change which, of course, you can see on the surface in the case of a river. If that change takes place in the ground water supply, it is due either to some mineral pollution getting into the stream while it is flowing down—and that you might expect to be fairly constant—or it is due to some surface pollution which you can, in this case, detect, because you can see what is going on at the surface. Therefore, this question of a change in the quality of the water is one that you have in your control. Where there is some mineral pollution through some subterranean fissure, discharging water from some lower and perhaps sulphurous rocks and so on, you could detect it now, and you have made your tests partly for the purpose of detecting such pollution. You did not find it. It is, therefore, pretty certain, quite certain, that it does not exist, because that underground water that you tapped is not a lake, is not standing water, but it is running water, and if there had been a pollution of that kind by a mineral substance you would have noticed it. You will find standing water, however, on this territory here and there where you have clay pockets, such as we find in the State of Washington and in Brooklyn. I understand you bored through clay in this case. Then you may get the surface water which trickles down into these clay pockets and stays there and forms dead water that will dissolve matter out of the clay, which may give it an organic pollution. You would get the running water, the live water, because, if you did not, your pump would soon be dry. Now, you have made your tests and demonstrated the reasoning which you can apply to this territory, and you will find that reasoning is correct. So I see no doubt whatever in regard to the conclusions.

GROUND WATER DEFINED.

Dr. Henderson—I will ask you to define ground water a little more definite in reference to artesian well waters.

Mr. Hering—Well, artesian well water, as I stated, requires a roof somewhere; otherwise, it could not get the pressure to come up above the surface; and that means it must be down pretty deep. These natural roofs are not as thin and impervious as our artificial roofs. They may be hundreds of feet thick.

Mr. Lindley—You do not consider this artesian water?

Mr. Hering—Well, artesian water, strictly speaking, is any water that will rise higher than the surface of the ground when it comes out.

Dr. Henderson—The point I wish to raise, Mr. Hering is: Can you define the lower limit of the ground water?

Mr. Hering—I understand that, as you bored these wells deeper the water came up higher. You bored through several clay strata.

Mr. Lindley—I do not think that has been demonstrated in that test out there; perhaps it has in the gas well bored here in town. Our deepest well was cased all the way, but I do not think it was determined that that water was higher in that well than in the other wells.

Mr. Hering—Well, of course——

Mr. Lindley—But it is higher here in wells which were bored for gas. Nevertheless, we are all familiar with the situation. That happened in wells that were 1000 feet deep.

Mr. Hering—Now, about three-quarters of a mile east of the city are those wells where a test was made—that is in what they call the "Henry wells."

Mr. Grau—That water was very hard. I do not know how deep the well was, but at the Buffalo Brewery we have three wells, one is 130, 170 and another one 210 feet deep; that water is very hard.

Mr. Lindley—Mr. Hering, you will remember it was the well we saw when we stopped at the brewery.

Mr. Hering—That is possibly due to the fact that it comes from a different stratum—where you have a material which is more readily dissolved by water—or it may be due to the fact that the water is held in that sand, like in a pocket. For a long time it does not run so fast, and, therefore, when water lies in contact with rocks that contain lime, it dissolves some of it, and therefore gets harder.

Mr. Grau—That underground water is further east or southeast.

Mr. Lindley—I may facilitate that a little by explaining that this district where we bored is of lava or hard-pan formation—ground that you covered in your remarks is all of that same kind. As we approach the Sacramento River to the northwest part of town, there are sedimentary formations and alkali waters, and if wells were bored where waters are alkaline until all that would be drained off, which might not be for many years, this water would naturally be a little harder. We find that existing in all waters as near as we can judge, which lie to the northwest of the Burns slough that runs along near and northwest of that brewery, and as we go west on all these waters and cross the Sacramento River they grow harder. In fact, looking at the history of the waters in this State, the waters which flow from the Coast Range mountains are several degrees harder than those which flow from the Sierra Nevadas; and the surface wells which are in the town of Sacramento, northwest of this slough, are different from those southeast of the city. In fact, there is one district to the northwest of this slough and in the city, which is called "Alkali Flat." Now, the water which flows through this alkali section would naturally leech out some of the alkali from the soil, and therefore become harder. Does this explanation seem reasonable to you?

Mr. Hering—Yes, sir; that is the condition of the ground. There is no question about that. But these isolated wells are not a safe basis upon which to judge the water you are going to get when you pump large quantities. You will remember, perhaps, that I stated in my opinion that nothing but an actual test, pumping out millions of gallons for some days, would decide the question of quality.

Mr. Lindley—Did you see the report of the test made at the beginning of the pumping, and at the ending of the pumping?

Mr. Hering—I think I did, but I do not remember just now.

Mr. Drescher—As I understand your theory, Mr. Hering, the idea is that this water, this ground water, flows like an underground river?

Mr. Hering—Yes, sir.

Mr. Drescher—And that on account of some of these wells somewhere striking unfavorable conditions, mineral or otherwise, the water may be changed from the natural condition, may assume some of the mineral, and that can only be found by actually testing it. According to your theory, water may be found in one place all right, and in another place not far distant you may find water, and, while the ground indications and the surface were the same, yet nevertheless you may find the water entirely different on account of the mineral stratum that contaminates.

DRAINS OUT POCKETS.

Mr. Hering—Please remember that, when you have a pumping station, you pump out 10,000,000 gallons to-day and 10,000,000 gallons the next day, and so it goes on until you pump out billions of gallons—that causes this water to flow better to your wells than at first. These little pockets that may exist now will be drained out, because you put the ground water level lower than it was before, and that causes these places gradually to drain out. And I may also state what I have perhaps omitted. In reference to lowering the ground water there has been quite a little discussion in the United States, particularly in the city where I live. The city of Brooklyn has been threatened with suits extending into the thousands of dollars for lowering the ground water.

Now, that seemed to be a very serious question in the minds of some; in fact, it was thought that the city would have to pay a large sum of money, because the farmers claimed that it injured their crops. They could not raise the same crops after 1894, when these particular wells that controlled that territory where the suits were, were opened. After that year the crops failed. Now, that seemed to be a pretty bad condition of things, and the first case was decided against the city. I was called into that case, and had to study up the matter and testify in a number of suits, and it was necessary to get evidence, not how much the ground water was lowered, because that we know from the tests, but what effect the rain water has on the elevation of the ground water, and how the ground water level affects the crops. You may at once recognize the fact that, if the ground water level is twenty-five or fifty feet or a thousand feet below the surface is is not worth anything to the crops. The question is, How near the surface must it be? Well, I searched in Europe and finally I found the best place to get that information was in Berkeley, California — from the University of California. Professor Hilgard had made some tests on that particular point. Later. I got some from Wisconsin. Later, last year, I found some in Germany, but the information is not very bountiful, but still it is sufficient to establish the facts, and my attention was called to the question, What will the damages amount to here in case the ground water supply is affected? Well, the experiments here in California indicate that the ground water level— the water, by capillarity, will rise during the dry season in different soils to different hights. In the coarsest soils and gravels it will rise only a very short distance, and nothing in the world will draw it up any higher. Sand will allow the water to be drawn up about eighteen or twenty inches higher. Clay, which has the finest pores, will draw the water up higher than anything else, and they found here that fifty inches was the maximum limit to which the ground water would be drawn up by capillarity, but that is in arid climate such as you have here. In Wisconsin the results were different. Roughly speaking, the coarser materials, of course, gave the same results, but inasmuch as the soil is saturated with water, or is moist, for it rains there every month in the year, and it keeps the water percolating through the ground constantly, and the water from the ground water level will constantly draw up higher, and there the maximum limit at which Professor King could find ground water rising up was ten feet, and that was in coarse clay soil; in sand, of course, it was very much less, not half that distance. And of course the same results were found in Europe. They will have to be found everywhere, because those are physical laws.

Well, now, that demonstrated that these farmers in certain cases, where they said that their crops ceased in the year 1894, and who claimed damages, never could have had any benefit from the ground water at all, and by lowering it below that level, if it could not benefit them, why it could not injure them. And so there was another point in these cases. In one case, there was a salt water slough between a man's property and the pumping station, so that it was utterly impossible for the pumping station to draw any water from his land, because his water went into the salt water, and the pumps never pumped more than just enough not to draw that salt water. They did not draw his water, which would have to run across the salt water into the pumping main—an absolute physical impossibility, yet that case was decided in favor of the complainant, and he got his $6000, and that case has been quoted all over the country, and he never should have had 60 cents, because the pumping station could not have drawn on his water. Then why did those crops cease to grow in 1894? What was the trouble? It happened just at the time when those pumping stations were put in. Well, I found in going back to the rainfall records, and raking up all the facts that we know, we will have some beginning on this subject. I found in 1894 there was a drought. You know the crops need water when they sprout, and then they do not need it at certain other times. Well, it so happened that, when the crops needed the water, there was none. It did not rain there for twenty odd days at one time, and then it rained when the crops were small. At the period of germination they needed a great deal of water, and they lost that power of growth, so that the crops were not good, and that happened in 1895, 1896 and 1897. We had a few years of drought just as you have had recently in California. They were at different years with us. And of course the farmers blamed the city for that unfortunate condition of things. And there the rainfall records show that beautifully, so that the recent decisions in those cases have been very different from the decision in the first case.

GOOD TIME FOR TESTS.

Member of Committee—Now, Mr. Hering, that may lead to a question in our case. Suppose that we had three or four dry seasons, would that affect the ground water?

Mr. Hering—There is no question about its affecting the ground water, and when I was here eighteen months ago it just happened to be at the end of those dry seasons. And I remember speaking to the gentlemen and telling them that you will have no better time, perhaps, to make your tests than just now, and the tests were made just at that time. Therefore, the results are safe, and if you discount it further, you can do so because there is no reason why you could not extend your gallery just like they do at other places and intercept more of this water. Therefore, again, there is no question about the quantity being sufficient, as you have a right to expect from your own experiments.

Mr. Hall—Mr. Hering, there seems to be a misapprehension at least on the part of some of this committee as to what water we are going to draw from. Now there is, and always has been, a prejudice against shallow wells. I think that, if we should say that we are going to draw the water from shallow wells, the people would be up in arms opposing any proposition for getting water from the east side. The committee and the people have always been laboring under the belief that we were going to tap some subterranean stream that would afford an ample supply of pure water, free from contamination of the shallow or ground water, as you term it, which water is found within fifteen feet of the surface of the ground. Now, of course, upon your theory we are going to draw entirely from the ground water, which we have always held to be objectionable. Do you mean to say that the rain water that is precipitated on the surface will come in contact with the ground water, or is the ground water independent of the surface water?

Mr. Hering—Because there are impervious strata of clay, twenty, thirty or forty feet thick, there is no chance of this surface water supplying the ground water in this immediate territory. Of course we get the original rain water that was precipitated at some point where it could enter these strata of ground water, but they are not in the immediate neighborhood of the city.

Mr. Hall—Then we would not draw any of the surface water and moisture from the farming section near by, as the surface water would not enter into the supply that we were pumping from, would it?

Mr. Hering—There is no question, in my opinion, that you would get no water worth speaking of, if any at all, from the immediate neighborhood, excepting what might percolate right along inside of your wells which you put in there.

LEGAL SITUATION.

Mr. Lindley—I would like to finish up on that legal point—that is, relating to the rights to the water I think that that is one of the most important factors here. And from studying the situation, it seems to me that we can eliminate almost entirely the objection as it appeared at Brooklyn—that is, that we may affect the crops. The only damage we could do would be in causing those using small wells to go deeper for the water obtained mainly by the aid of windmills.

Mr. Hering—That is unquestionably so; but there is another matter which must be taken into consideration, but for which the damages would be very light, and that is the lowering of the ground water which is now pumped up for local use.

Mr. Lindley—The only question is whether we would be liable for damages if we compelled these people, who have been using this water for years and years, to use extra power to raise this water—would we have to compensate them for the extra power?

Mr. Hering—I would say that you would have to compensate them for whatever damages they have suffered and which were caused by any action of yours; but, as you say, that is confined to this small area which we call the "cone of depression." It is very small and it would affect but a few wells, and the damage would be so slight that it would be a great deal better to do what they neglected to do in Brooklyn—namely, to go to those people and get a release from them, or pay them something, so that there will not be any lawsuits afterwards. If the city of Brooklyn had done that, it would have saved money but as it is, damages will have to be paid to a certain extent.

Member of Committee—What would that damage be in a case like this?

Mr. Hering—So far as the information which I have goes, it is physically impossible to damage their crops by the water that you take out. Where you lower the wells there would be a slight damage, but that is insignificant.

MATTER OF CESSPOOLS.

Mr. Hall—The point is whether or not the local precipitation or surface water will come in contact with and affect the ground water. You spoke about the cesspools being liable to contaminate the supply if they were sunk six or seven feet deep.

Mr. Hering—Well, I want to be very cautious in all of my work, and so I alluded to all those things which might be thought of by persons, and wanted to consider them and give them their value, and that is the reason I mentioned them. But I will say that, from the near territorial area within a mile or two of these wells, you would probably get practically no surface water at all, not only because of the clay strata, but because of the fact that you would get very little water anyway from a square mile. The calculations that are made indicate that the quantity might not be more than 100,000 gallons in one mile of territory. You will need 10,000,000 gallons eventually. You may, therefore, have to draw from 100 square miles and more, and would get very little from this near territory, because you are drawing the water under clay strata, and most of it comes from a greater distance. Therefore, that difficulty, the more you look into it, disappears more and more, and it is quite insignificant even should it exist at all.

Mr. Hall—Mr. Hering, we find this ground water at a depth from twelve to fifteen feet below the surface, and if we put in pumps we lower it perhaps to twenty-five feet, and this is the water that you are going to deal with. Now, the idea of this committee has been that the wells should be put down with a double casing until an impervious strata of clay has been reached, and then continuing down with the inside pipe to a good water-bearing strata of sand or gravel, when the water developed would raise in the pipe up as high as, and flow into, the conduit, which would be water-tight and no water would come into it except from the wells. Your theory is entirely different from ours, as you deal with the shallow ground water which we have been trying to avoid. We were intending to go down and tap some independent strata of water below the clay stratum. That is the idea that has prevailed with many of the committee, and is the impression, I think, that has gone out among the people: that we must get a supply of water below this ground water in order to avoid pollution or contamination.

Mr. Lindley—There is nothing in the report of the Committee on Wells that bears that out.

Mr. Hering—I certainly never got that impression. Moreover, the contrary seems clear and evident in that report from the very fact that you have lowered the surface water in drawing from those wells.

Mr. Hall—That is what we did.

Mr. Hering—In my preliminary recommendation I stated that before any tests should be commenced you should go to all the existing wells—I stated about how far—and take the level of the surface water before you began pumping, so that you would know how far the pumps drew. There was no anticipation that you were not going to get that water. The test was made for the very purpose of getting it. You do not know what you are getting when you go into deep wells. But this water that is not so far down is within our grasp; we know about it and we can control it. We know what it is, and it is nothing else in the world but the same water you get in any dug or driven well. Rain water is the dirtiest water that we have except sewage. Bacteria are necessary to purify dirty water, working by the myriads. We cannot raise plants without the action of bacteria. This water, which is charged with impurities on the surface of the ground, percolates down, is purified and supplies our springs. The surface water is the dirtiest water, and by the percolation it has become pure. When we can select the sand and have everything perfect, we require only three feet of slow percolation through the sand to purify the ordinary river water. Five feet would purify the strongest sewage that we have—make perfectly good water of it. The well water that we would get would be similar to, and even better than, the water that we now get from these wells twenty or thirty feet deep. If you pump out the water by the millions of gallons, clay pockets do not count. You could pump them out in a short time.

Mr. Hall—Perhaps it is just a misunderstanding of terms.

Mr. Hering—It is a very good thing to explain terms before beginning a discussion, because many misunderstandings arise from the fact that one person understands one thing and another understands something else, and so of course you are really not talking about the same thing. By ground water, I mean that water which is found here under this ground, about twelve feet below it. It is found about that far below the surface of the ground, and it is the upper surface of the body of water which has a slope of about four feet to the mile and is running in a southwesterly direction. That is the underground flow of water which you should tap.

Mr. Hall—I understand thoroughly what you mean. I only make these statements because there is a misapprehension on the part of some members of this committee and on the part of the citizens generally. We always considered it absolutely necessary to go below this ground water and take a supply from the deep subterranean channels that probably take their source 100 miles distant.

PUREST WATER IN NATURE.

Mr. Hering—I should not call that ground water shallow water, excepting in contradistinction to artesian water. But whatever name you give it, the water I mean should not be understood to be the water that is polluted from the surface, but that water which has been purified in its passage through the soil by bacteria. The water, at the surface of the earth, is that which percolates through the upper layers and forms the spring water, or rather the ground water which supplies the springs, and which is the purest water that we have in nature, and its purity is obtained by the action of bacteria alone. A filter must, therefore, be so constructed that the bacteria can act. If the water gets cold, many of them die off. If you put a little poison in the water, you kill the bacteria, and the water won't be a bit purer when it comes out than when it goes in. Nature has been following this method of purification for thousands of years. You cannot get good water immediately through your filter, as it takes time to adapt the bacteria to do their best work. They do not get ripe, as they call it, at once. They do not get ripe for a few months. Then just the right species are there, and they begin to do their work up to their greatest ability. In this way we purify the foulest sewage matter by slow percolation through only a few feet of the right kind of sand.

Member of Committee—Now, Mr. Hering, why is it, in most cases, the wells are double cased and filled with cement, you know, down forty or fifty feet? Isn't it done for the purpose of preventing the water outside from running along inside of the wells?

Mr. Hering—That may have been stated as the purpose.

Member of Committee—Well, they generally have a shoe running down?

Mr. Hering—Yes, sir. But the reason for that sort of protection originally resulted from the fact that the surface water would run down on the outside of the pipe. Let me say that, whenever we have a smooth surface, such as the outside of a pipe, and have gravel stones around them and sand, we have larger interstices adjoining this smooth surface than away from the surface. A great deal more water runs right along the smooth surface through the larger interstices than away from it, and runs down without purification. It does not purify at the greater depth. The bacteria need oxygen. That is the reason I said you should have shallow cesspools on the gathering territory for the water. The polluting elements should not enter very low, as the bacteria are thus deprived of the oxygen which they need. Twenty years ago very little was known about this subject. Pasteur started it, and since that time the Germans and English have developed it, and in Massachusetts the State Board of Health has placed it on a scientific basis. We can now take the sand and analyze it mechanically, get the proportions of the sizes of the grains, and foretell how much sewage of a certain strength, how much water with a certain amount of oxygen and a certain amount of organic matter in it, can be purified by percolation at different rates.

WELLS SHOULD BE DEEP.

Mr. Lindley—Mr. Hering, I think that Mr. Hall touched on a point that it would not hurt to discuss, because it is something that will have to be talked with the people of the town when the question comes up, and that is the difference between a house well, such as used here in early days, and the wells which we bored and tested southeast of here. The people have a prejudice against those house wells, and they naturally will attribute all the evils of those wells to the wells proposed for the city.

The Chairman—I think Mr. Bishop is familiar with the digging of wells and the depth. It would be well if he would tell us about what depth one would have to go before he can find anything that seems permanent in a supply.

Mr. Bishop—On an inspection east of the city we find what we consider the best water there from sixty to seventy-five and eighty feet for family use. In the surface water wells there, twenty or twenty-five feet deep, the water is very poor. The people out there using that kind of wells are sick all the time, mostly with malaria. Pretty near all of them are made deeper now. They have a soil there from one to three feet deep, and they have what they call hardpan, and then it usually tapers off into sand. When they first strike ground water, then there is sand and gravel down about twenty-five or thirty feet—it varies somewhat. Then we find a body of clay varying from ten to thirty or forty feet thick. People using water coming from that depth below the clay stratum do not get sick at all.

The Chairman—Now that leads up to a question. I understand you to say that below the soil there is the hardpan, and then below that is sand. At what depth do you strike that sand?

Mr. Bishop—In some places there is sand about twelve or fourteen feet.

Mr. Hering—I do not know whether it is so here, but the custom is in many cities to dig cesspools down until they strike sand, so that the water from them will percolate into the ground and disappear and not fill up the cesspool. It is then called a leeching cesspool. Now, then, that is a condition which will unquestionably pollute the water in that stratum of sand into which your cesspool discharges. That is why I say the cesspools should be shallow, and the bottom should be near the surface where the bacteria could purify the water. I mentioned that this condition was the only one that affected the quality of the water, which you should understand and know about. You can prevent it legally, because it is just as objectionable, and perhaps even more so, to pollute an underground stream of water, as it is to pollute a surface stream of water. As soon as it is established that the ground water makes a running stream—I don't know just how the law is in this State, but in some of the Eastern States a stream cannot be polluted, whether surface or sub-surface, and the law seems a reasonable one—you should, therefore, see that your underground river is protected from pollution. Take the city of Louisville, Kentucky. They have flowing under that city just such an underground river as you have here. The slope of the water is just about the same. The city is also built on a slope, and they have pump wells to supply the poor people with water at almost every block. Many people want that clear ground water.

They have been drinking it, because the Ohio River was so turbid and dirty. And yet in that very city, and on the higher grounds where all the wealthy people live, the cesspools were dug down directly into that same stratum of sand through which this water flowed down to the lower parts of the city. When I was examining that city, I had a small keg of coal oil put into a cesspool on one of the lots up town, and within a few days the pumps below were complaining because the water of the wells tasted of coal oil. You must not get your cesspools down deep enough, so that this water in the cesspools will leech out and be at a level below which it cannot be purified by the only purifying means that we know of—bacteria. If you have the shallow cesspool, such as they have in the country houses, here as well as in the East, why there is no such danger. The water percolates laterally into the soil near the surface—I mean in shallow cesspools.

Mr. Scott—I know a man up here on E Street who dug two cesspools, and then dug a well and the water from the cesspool goes into that well.

Mr. Lindley—Now, there is a great difference between one of these wells, which are used moderately, and such wells as are proposed for the city water supply. In other words, there should be no prejudice against those wells on account of the prejudice that exists from slightly used, shallow wells that existed here in early days.

Mr. Hering—No; and there is still another reason. You look at the map. This water comes from the east and it flows in a westerly direction, and then turns down in a southwesterly direction and passes by the city of Sacramento. There is very little circulation, if any, of the water right under this city. It is off the line of flow. I hardly think that you get any circulation of water under the city. There is no apparent reason for it on the surface. All the apparent conditions would make you think that there could not be any, and that is more or less dead water.

The Chairman—The Sanborn well, how would it be in that locality?

Mr. Lindley—Right in there are some wells. We drove around here and struck the railroad over here and came in that road. Now, right off there is the Sanborn well. Here were the test wells. (Pointing to the map.)

The Chairman—Would you think there is a circulation there?

Mr. Hering—There are no indications that there would be any circulation there. I think this map shows better. Here is the American River. Here is the Cosumnes River, and the ground water flows like that (showing). The next map shows where the water comes out.

WHERE TO SINK WELLS.

Mr. Grau—Where are the test wells here now? Now, suppose the city would buy a large tract of land, which way would they have to go?

Mr. Hering—They would have to go southeast from these test wells.

Mr. Hall—The strata of water 150 or 200 feet below the surface, being below the sea level, do not flow like the surface or ground water.

Mr. Hering—The further down you go the less natural circulation the water has.

Mr. Hall—In all of these deep strata there would be absolutely dead water unless there was a break somewhere in the formation of the ground, which would permit it to be forced to the surface by artesian pressure.

Mr. Hering—The same water may have been lying in these reservoirs for a thousand years and may never have moved. Take an artesian well. The water must come up to the surface to flow. All water that flows to-day has got to have its outlet above sea level.

Mr. Lindley—Have you the geological map of this section?

Mr. Hering—I have not the geological map of this territory. I have asked for it, but it is exceedingly difficult to get.

Member of Committee—There is one point, Mr. Hering, with reference to the ground water. Suppose the citizens would demand water coming from a hundred miles, is there any reason why the larger part of this water does not come a distance of at least 100 miles?

Mr. Hering—Some of it comes from a distance of more than 100 miles.

Member of Committee—These deep cesspools that we do not control—to what extent do we have to control them?

Mr. Hering—I mentioned the effect of deep cesspools to you, but it would be insignificant in your case. A few of them, in that vast territory, would be an insignificant factor. Now, take Brooklyn, for example. That city is growing out over these wells where they are pumping ground water. Ten years ago the Long Island Water Supply Company had a plant of wells supplying the town of New Lots. It wanted to sell, or the city wanted to buy. There was a committee appointed to take testimony on the valuation of the supply. I was one of the witnesses for the city. My testimony was to this effect, that, in fifteen years, the population would have increased on that territory to such an extent—I forget now how many per mile—that the water would no longer be fit to use, because there would be so many cesspools, sewers and all that to pollute the ground water. That water to-day is almost objectionably polluted. A valuation which was given at that time would be almost nothing to-day, because the water is gradually becoming polluted. If your city grows out to the wells, gentlemen, you want to examine that water very carefully, and perhaps finally abandon it.

ESTIMATED COST.

Now, let me tell you something more, gentlemen, which I have not yet told you. On a 10,000,000 gallon basis, there is a saving of $23,000 a year to the community by using the wells over using filtered water. In five years that would be $100,000, and in ten years it would be $200,000. No serious pollution can take place there in ten years, and you have got $200,000 in your pockets. Even if you change your supply at that time, you have saved that much money to help make the change.

Mr. Lindley—Now, suppose in the filter plant that the actual results show that there is 2 per cent of the bacteria in water. Now, what would be the relative difference between the 2 per cent of bacteria that would be left after filtering river water and the pollution which would naturally be caused by agencies affecting wells?

Mr. Hering—You could not detect it at all. The number of bacteria in water is something extremely elastic. I think, though, you ought to do better than 2 per cent. But this calculation of percentage is altogether misleading. The Germans have the only right standard The percentage is no criterion. You should fix your standard by saying we will have so many bacteria in a given amount of water. The German standard is 100 bacteria to the cubic centimeter.

Member of Committee—Compared to the liability of pollution from any new feature of that kind developing there, there would be the same liability, or even greater liability, if the river water were used. would there not?

Mr. Hering—The filters, if they are always properly operated, should keep these bacteria out.

Dr. Henderson—Our river water has only about 500 or 600 bacteria to the cubic centimeter.

Mr. Hering—It depends altogether on what class of bacteria you have. Of disease bacteria, you do not want one in the water, if you can keep it out. Fortunately, we have found that the typhoid bacillus may be kept out by the filters. This is evidence of an inductive kind, which is very strong, that the filters do keep these bacteria out. We know what the death rate of typhoid fever and certain diarrhoeal diseases has been before filters had been introduced. Then filters were introduced into a city and the death rate of typhoid fever and diarrhoeal diseases dropped immediately. That has been the case in England and Germany, with no exception. It has been the case in our country where the examinations were made. As soon as you have filtered water, typhoid fever goes down.

ALUM IN FILTRATION.

Mr. Lindley—Now, if that water could be cleared by half a grain of alum by the mechanical process, would not that be an indication that it could be filtered by the slow sand filtration process?

Mr. Hering—Not necessarily; no, sir.

Mr. Lindley—What I mean is, the trouble in the slow filter would be fine suspended matter, and would this half grain of alum conquer that?

Mr. Hering—Oh, much less than that on the average, and only at such times when this turbidity caused by fine clay exists. I do not think that condition exists all the time. In Washington we expect to use alum for about ten days in a year; on the other days it would not be necessary.

Member of Committee—Now, Mr. Hering, what becomes of the alum that is used in filtering water? There are some of the gentlemen here who are afraid as to what becomes of it. Does it ever go into the water?

Mr. Hering—If the water is hard enough to re-act on the alum which was put in, and if you do not put in any more alum than is necessary to offset the lime that is in the water, why no alum at all goes through filter.

Mr. Lindley—If it is filtered intelligently, there is no trace of alum in the water, is there?

Mr. Hering—If you have no lime naturally in the water and yet must use alum, then you must also add lime to the water, so that the alum will re-act. If the work is done properly, there is no reason why filtered water should not be as good water as you could get. There should be no alum left in it.

Mr. Lindley—Have you compared the two different qualities, according to the analysis, as regards manufacturing? It is claimed that the water from the wells has sufficient hardness to make it much more undesirable for manufacturing than the river water. Have you determined anything on that?

Mr. Hering—I have not. If you use mechanical filters, your water will be made harder, but not as hard as the well water now is.

Mr. Lindley—Is the difference between the hardness of the river water and well water worth considering?

Mr. Hering—No, sir; it is not worth considering. I think, in further answer to your question, that the hardness of this well water, when it is taken out of ground in large quantities, will be less than it is now.

Mr. Lindley—Have you followed the analysis to know what the hardness of the well water is?

Mr. Hering—Four and a half degrees, I think.

Mr. Lindley—Now, in reference to your estimate of expenses.

Mr. Hering—You can have this in any detail that you want. This is only the summing up of the annual cost which I have here, the interest on investments, and the operating expenses. Mr. Le Conte has the details.

The Chairman—I am sorry that Mr. Hering says that this is the last night he can be here. Mr. Le Conte will be prepared to give us his report in a few days. Mr. Arnold, have you any questions to ask?

WOULD LAWSUITS FOLLOW?

Mr. Arnold—The only thing that I took any particular notice of is pumping at the wells out at Florin, and all the lawsuits we will have. It looks to me, from the account here of Mr. Hering, like it will have something to do with it. If we pump 10,000,000 gallons a day, as you suggested here, we will be very likely to draw from the fruit lands more than fifty or sixty miles around. You will draw from the east, southeast and northeast.

Mr. Lindley—Those people are drawing water from a distance of about twenty feet. They draw from twenty or twenty-five feet. That is as much as their pumps can stand at the present time. Suppose, now, that we lower their water fifteen feet.

Mr. Hering—Show me where it is and I will explain it.

Mr. Lindley—(Shows.)

Mr. Hering—Well, you could not possibly lower it.

Mr. Lindley—Could you lower it at all?

Mr. Hering—I doubt very much whether you could lower it at all. This test would not have been worth five cents if that conclusion could be drawn. This test was made for the purpose of finding out how much you could draw there, apparently, without permanently lowering the ground water beyond the cone of depression.

Member of Committee—You do not think that any further test is required to establish that fact?

Mr. Hering—Not to establish this point. If there had been any doubt left, I would have told you so, because an engineer never wants his recommendation to turn out incorrectly, and he never wants his work to be a failure. That is the reason that I have given you all the bad points, as well as the good ones, that I know of in this matter. It is of no interest to me to tell you something that I do not think is right. In fact, I have recommended more filter schemes than ground water supplies. I am really more interested in filtration. Since the last ten years I have been one of the few engineers who have been engaged on that subject, and on every occasion I try to get people to filter their water, but I always recommend the cheaper of any two schemes, when I think them equally good.

Member of Committee—You suggested that we run more in this direction, southeasterly (pointing to map).

Mr. Hering—Yes, sir.

Member of Committee—Would it not be a good plan for the city to buy a large tract of land?

Mr. Hering—You cannot buy all the land from which the water percolates down to your strata, but what you want is to have land enough upon which to put your wells and your machinery. That is all the land you would require in the immediate vicinity. You would want a strip of land there long enough and wide enough for such a purpose.

Member of Committee—You would want a piece of land large enough in order to be safe against injunction?

Mr. Hering—Well, I would get a release from all the property owners before starting the work.

Member of Committee—Release instead of acquiring the land?

Mr. Hering—Yes; perhaps that release would be sufficient. You can get that release sometimes on condition that you will pay so much a foot for the water as it is lowered in the well. Then, gentlemen, don't miss the opportunity to get levels of all the wells you can everywhere around in the neighborhood. Likely some people may sue for some damage that has never been done. Get the hydrographic records of this territory before starting, as far as the ground water is concerned. Establish your proof for the present time. If Brooklyn had done that, she would have saved $50,000.

Member of Committee—Where there is a liability of incurring damage, would not it still be more desirable to use the well water?

OF EQUAL MERIT.

Mr. Hering—If it is only a money question, gentlemen, you have the estimate of cost. You save $23,000 a year. I have tried to cover the ground this evening on those two points—efficiency and cost. I consider the two projects practically of equal merit, as regards the water, but the well supply much the cheaper one. Now, I will tell you what I should do if I were the engineer of this work. I would bore some wells to find out where this ground water was naturally coming out on the surface. I would go down perhaps five feet below the surface near the swamps south of the city. Now, if that water were flowing all the time, you can be sure that the water you propose taking is going to be good water, because it is the same water that comes out of this land, and demonstrates a continuous current.

Member of Committee—How much is that water lowered now (pointing to the map)?

Mr. Hering—Thirteen feet. At twenty-six feet below the surface your cone of depression went out that far (1500 feet). If you lower the level more than this, you can find out approximately, by a parallel line, where the new starting point of the cone will be.

Member of Committee—Then you think that would be definite enough for us to base all estimates of damage on?

Mr. Hering—Yes, sir; in such a case you know very nearly what is going to take place. Make your arrangement with land owners for so much a vertical foot of lowering. Merely to save yourselves from unjust suits, you want to get all this information beforehand, get it settled and make your contracts and so on. I made no estimate for such damages at all. It is a very small amount.

Final Report of L. J. LeConte.

SACRAMENTO, Cal., May 27, 1901.

General Lewellyn Tozer, Chairman of the Water Committee of Sacramento, Cal.—Dear Sir: In compliance with your verbal instructions "to drop the matter of the city pipe system temporarily and take up the matter of making a special report on the East Side Wells scheme, together with an estimate embracing the probable cost of constructing the proposed East Side pumping station, wells, auxiliary reservoir, force main leading from the proposed station following the county road to a point near the intersection of Thirty-first and P Streets, at the present city limits." I have now the honor to submit the following report:

PRESENT STATUS OF THE EAST SIDE WELLS SCHEME.

The final results of the well-testing operations in January, 1900, are familiar to all the members of your honorable committee, and therefore, all that can be said further in the matter is to clear up some doubtful points bearing upon the quantity of water which can reasonably be expected, by proper development, from pumping stations located in the East Side Well district.

In reconsidering the results attained, two highly important features must be held constantly in mind. First, that the time selected for testing was at the end of the most prolonged drought known in the history of the State of California, and for that reason the results would necessarily have unusual weight in deciding upon the minimum amount of water which could be obtained from any given pumping station. Second, that when the pumps were going full blast the ground water at the wells site was only depressed thirteen feet below its original level, which is exceedingly moderate. That the pumps were all doing their level best and delivering 4,500,000 to 5,000,000 gallons per day; but that local conditions were such that the small pumps in use were unable to pump any more than this amount of water. Hence it necessarily follows that the testing operations, in point of fact, simply determine the capacity of the little pumping plant in use, and did not properly determine the true intrinsic value of the water-bearing strata in the East Side Well district. I will now proceed to submit well-known facts to substantiate this statement.

BROOKLYN—NEW YORK.

The most extensive and reliable ground water supply in the Union is that of Brooklyn, New York. The city has a population of 1,000,000. The present daily consumption is something over 80,000,000 gallons per day. Half of this water is derived from pumping stations located in a district underlaid by water-bearing strata of sand and gravel. In testing the ground for sites for new stations, in 1896, a 5,000,000 gallon testing plant was used. This was regarded as ample for the purposes held in view, and it was found by actual trial, lasting twenty-eight days, somewhat intermittent, that a continuous draft of 5,000,000 gallons per day would cause the ground water to lower fourteen feet at the station, and after pumping operations had ceased the ground waters recovered their original level in twelve days. Now, turn to our own East Side Wells and see what results we have obtained from our groundwater district. By actual trial extending over six days, or 144 hours' steady pumping, we found that the ground waters subsided at and near the wells just thirteen feet by reason of a steady draft of 4,500,000 to 5,000,000 gallons per day, and when the pumping test came to an end the ground waters recovered themselves and resumed their old original levels in four days. It is clear, then, that the Sacramento wells developed the same depression of ground water as the Brooklyn wells, for the same draft—namely, thirteen and fourteen feet respectively—and that they certainly recovered from the effects of a 5,000,000 gallons per day draft much more rapidly than the celebrated Brooklyn wells. These potent facts all point unmistakably to the conclusion that the flow of underground waters in the East Side Well district is of immense volume and thoroughly reliable as a source of water supply for the city of Sacramento. Your honorable committee is, of course, more particularly interested in the question as to the development of water supply from this district to its possible maximum.

By reference to the blue print map herewith submitted, prepared by me in December, 1899, showing the topographic and hydrographic features of the East Side district, you will observe that the width of the belt of underground flow which was intercepted during the well-testing operations in January, 1900, was about one-half mile only. Farther south in continuation of the line of wells, we have the same water-bearing strata extending for a distance of 1.5 miles at least. This underground flow was entirely unaffected by our pumping operations and is certainly available for future extension of the water works in that direction whenever future demands may call for it. Inasmuch as the width of the unintercepted flow is fully three times that of the intercepted flow, which we know developed a supply of 5,000,000 gallons per day, we are fully justified in assuming that this district is capable, with proper development, of supplying at least 10,000,000 gallons per day, and it is highly probable that the yield may be 15,000,000 gallons per day. Finally, in view of these well-established facts, I am of the opinion that the proper first step to be taken by the city of Sacramento for obtaining an improved water supply would be to establish a 10,000,000 gallon pumping station, with a suitable system of wells, in the East Side District, and supply the city with good, pure water from that source.

(See report Brooklyn Public Works Department for 1896, page 128.)

The next point to consider is that of the cost of the proposed pumping plant.

The following is an approximate estimate of cost of constructing the proposed East Side pumping station, wells, auxiliary reservoir and force main leading from the station, following along the county road to a point near the intersection of Thirty-first and P Streets. The proposed plant is designed to have a capacity of 10,000,000 gallons per day.

APPROXIMATE ESTIMATE OF COST OF A 10,000,000 GALLONS PUMPING PLANT AND SUPPLY MAIN.

Force main from the pumping station to the city limits, two miles of 28-inch riveted pipe	$38,206

Twenty wells (12 inches diameter).........	7,200
Twenty manholes and a horizontal connecting main from wells to pumping station	54,263
Pumping station complete, two 10,000,000 gallons pumping engines and five 200 horse power boilers	108,000
General pumping expenses during construction	10,800
Auxiliary reservoir, 6,000,000 gallons......	16,200
Contingencies, engineering expenses and superintendence	26,000
Total	$260,669
Land purchases?......................	
Rights of way?	

ANNUAL OPERATING EXPENSES.

The most important feature connected with a city water supply is that of annual operating expenses. For the particular purposes of this report all that is necessary or desirable is to know the cost of operating and the delivery of water at the city limits. In order to facilitate comparison with other rival schemes, it is assumed that a consumption of 10,000,000 gallons per day is desirable as a basis for calculations.

PUMPING OPERATIONS.

Ten million gallons per day, 3650 million gallons per annum, at $12 per million gallons	$43,800

DEPRECIATION.

Well casings, life forty years, per annum......	$50
Cast iron pipe, life 100 years, per annum......	224
Pumping engines, life twenty-five years, per annum	2640
Five boilers, life twenty years, per annum.....	1500
Two miles supply main, life forty years, per annum	1061
Engine and boiler houses, 100 years..........	260
Total	$5735

GRAND TOTAL ANNUAL EXPENSES AND INTEREST ACCOUNT.

In order to make financial comparison with the different rival schemes for water supply possible, it becomes necessary to consider three fundamental items:

Annual interest on total investment at 4 per cent	$10,426 76
Annual operating expenses of pumping station	43,800 00
Annual depreciation of perishable material in the pumping plant and pipes	5,735 00
Grand total annual expenses	$59,961 76

In round figures, say $60,000 per annum, is the financial value of the East Side Wells scheme, on the basis of a reliable supply of 10,000,000 gallons per day of good, pure, flowing ground water, which is by nature spring water.

This supply does not require filtration.

Respectfully submitted,
L. J. LE CONTE, C. E., M. Am. Soc. C. E.

Majority Report.

From the foregoing reports and investigations made, the undersigned, members of your committee, find as matter of fact:

1st. That there is no question as to the quantity of water and the continuity of flow in the Sacramento River. It is an ample source, not only for the city's present needs, but for any future requirements. Of this Mr. Hering in his report says: "With reference to the quantity, not a word need be said about the abundant quantity of water in the Sacramento River. But the quantity of water to be found in the underground strata is an important matter; and, as we can not see it running on the surface like water from springs, or in brooks or rivers, we must have some other means of finding out its quantity and that is largely by inductive reasoning." In the minds of the undersigned members of the committee, the question of a permanent quantity to be found in the wells sufficient for the needs of the city, even at the present time, is a very doubtful element, and is involved in great uncertainty and can only be solved by actual demonstration.

being, operating a filter, is apt to slip up sometimes, and it is at least as probable that you will get unproperly filtered water, as polluted ground water, under the particular conditions of your case mentioned above."

We agree with the "Purity Committee," whose report says (page 73): "It is the opinion of this Committee that, owing to possible lack of care or ideal conditions at all times in the practical operation of a filter system, the well supply would prove the more constant or uniform in quality of the two systems proposed."

As to the permanence of quality, we agree with Mr. Hering—"I therefore feel quite confident that the quality of the water will always remain as it is. Its present softness is, in part, a confirmation of that conclusion, because it shows that the territory must be of such geological formation as we see it to be from the surface indications."

The slight difference in hardness between the well water and river water will be materially reduced, if not entirely overcome, by the increase of hardness of river water, when subjected to a mechanical process of filtration. Well water has been analyzed from the district where it is proposed to locate the wells with results as to hardness the same as that of an analysis of the river water at Red Bluff, where it is supposed to be more desirable as a drinking water than is the river water at Sacramento. (See analyses reported by "Purity Committee," page 73.)

Any pollution of the underground water, (a condition most improbable), would be a matter for regulation by our local county legislature, of which we may reasonably expect to have control, while pollution of the river, an existing and increasing condition ,would be more of a State or inter-county affair, in which we would not have so much influence, and so long as we use the river for disposal of our sewage, we would be influenced in restricting such pollution above us by the danger of subjecting ourselves to the expense of a very costly change in our sewerage system.

2d. QUANTITY.—We agree with the statement of our colleagues of the majority, substantiated by quotation from report of Mr. Hering, in reference to the quantity of water and the continuity of flow in the Sacramento River. However, it was not to establish this fact that we called Mr. Hering from the far East. We did call him rather to decide by scientific reasoning, not only the question of the sufficiency and permanence of the supply to be obtained from the East Side wells, but to consider and decide upon the relative merits of both the river and wells. Concerning the latter, in his report, Mr. Hering says: "It is entirely safe to have an estimate of cost on 10,000,000 gallons of water a day, such as Mr. Le Conte prepared, and I am confident you can get much more. There is no doubt at all about it; and the beauty of a system of this sort is, that you can readily extend it as you need more water." Also, "So far as the quantity is concerned, I am therefore satisfied that we have enough water here (East Side wells) for your purpose." Whereas, in the opinion of the majority, unsubstantiated by expert authority, the question of a permanent quantity to be found in wells sufficient for the needs of the city, even at the present time "is a very doubtful element, and is involved in great uncertainty and can only be solved by actual demonstration." With all due respect to the opinion of our colleagues of the majority, who, with ourselves, for two years have given this subject earnest consideration, we must defer to the opinions of the experts, who have devoted many years of study to solving similar questions in many localities, and whom we employed to study this question.

If we have not solved the problem of sufficiency or insufficiency of the ground water supply, we, as investigators, have not performed our full duty and the Committee should ask for further time and consequent appropriations to expend upon tests or upon expert testimony upon which we can rely.

Mr. Le Conte says: "By reference to the blue print map herewith submitted," etc., etc., and after stating the width of the belt of underground flow, intercepted to be about one-half mile, he goes on to say "The same water bearing strata extends at least one and one-fifth miles further south, and which was entirely unaffected by the pumping test," and concludes by saying, "Inasmuch as the unintercepted flow is fully three times that of the intercepted flow, which we know developed 5,000,000 gallons per day, we are fully justified in saying that the district is capable, with proper development, of supplying at least 10,000,000 per day, and it is highly probable that the yield may be 15,000,000." We agree with him in all these conclusions.

Particular attention is called to the map above referred to (see page 110), which shows the approximate limits of the water depression caused by six days continuous pumping and which was one-half mile wide by one mile long, and this, it must be borne in mind, covers all of the land wherein the water level was affected, so it is reasonable to conclude that by extending the system of wells another half mile south it would produce nearly or quite double the amount of water and correspondingly extend the southerly limits of water depression, and, therefore, would not affect the water level beyond the limits of one square mile, and about half this extent would be affected only to a slight degree.

Much larger cities than Sacramento have had underground water supplies for many years; e. g. Dresden, population, 280,000; Munich, 350,000; Brussels, 500,000; Budha Pesth, 500,000; Lowell, Mass., 90,000; and many others, besides those cities which are supplied wholly or in part by well systems, as Brooklyn, N. Y.; Frankfort-on-the-Main, Vienna, and others.

3d. COST.—The only estimates which we can recognize as a basis of calculation are the official estimates of Engineers Le Conte and Wagner, which were accepted by Mr. Hering. Adding to Mr. Le Conte's estimate the cost of land, which is not included in his estimate, certainly not exceeding $20,000, the cost of well supply would be $280,000. Upon this added amount there would be no depreciation. Accordingly this increased cost would affect the annual expense only by increasing the interest account about $1,000. This would reduce the annual saving estimated by Mr. Hering from $23,000 to $22.000. In thirteen years the annual saving of $22,000, applied as a Sinking and Redemption Fund, would liquidate the debt involved in establishing the well system.

This amount is equivalent to the interest on $550,000 at 4 per cent. per annum, an item which taxpayers can not afford to ignore.

Twenty-two thousand dollars is 30 per cent. of the present net proceeds ($73,595.91 for the year 1900) from our water works system, which is now used to decrease tax rate; $22,000 annually invested in extra municipal improvements would do much to make Sacramento a model city.

Any extra land purchased for protection against possible pollution or legal complication, would serve as a site for a needed park and be an attractive feature of Sacramento.

The risk which the majority fear in establishing a water plant at the site of the wells is nil compared with the absolute certainty of expending an extra $22.000 annually for filtration.

The figures on filtration are made on a basis of an economical handling of the filter plant, even to the extent of eliminating the cost of maintaining a laboratory to insure uniformly correct purification, a questionable economy to say the least.

The argument of the majority to the effect that when it becomes necessary to increase the supply from 10,000,000 to 16,000,000 (a supply sufficient for more than 100,000 population) "The additional filters can be installed for a very small sum compared with the cost of developing 6,000,000 gallons more from the wells," has been answered by Mr.

Hering, in reference to quantity at well site, when he says: "There is no doubt at all about it," as already quoted above, but even if their statement should prove true, by the time the city will need an extra 6,000,000 gallons of water, the adoption of the well system will have saved enough money to buy two filter plants.

The statement is made that a "considerable additional expense will be incurred by means of reversing the system of pipes for distribution purposes." This statement is misleading, for no change will become necessary, but simply larger mains will be required for the eastern and southeastern part of the city. Our citizens in that quarter of the city are entitled to some consideration, especially as the city is growing out in that direction, and this item of cost will not exceed the saving of one year by the proposed well system.

The majority suggest the possibility of legal entanglements. To this we answer: The savings of a well system would be sufficient, not simply to buy releases, if such were necessary, but to buy the land for miles around the plant.

Finally, it is but proper to say that Mr. Rudolph Hering is one of the leading authorities of America on water supply. He has studied the subject in America and Europe. His practical experience is great. His reputation is international. Such cities as Philadelphia, Washington, New Orleans, etc., have sought and followed his advice, and we can see no reason for refusing to accept his recommendations, particularly as his opinion is the only expert opinion we have obtained, and it is not at all likely that he would jeopardize his professional reputation in recommending a water supply, the success of which might prove doubtful.

The choice is between river water and water that is practically mountain spring water.

In conclusion we recommend the well system, because of—

1st. Superior quality of water.
2d. Sufficiency of quantity.
3d. Economy of expense.

Respectfully submitted,

ANDREW M. HENDERSON,
D. A. LINDLEY,
LEWELLYN TOZER,
A. MEISTER.

S. LUKE HOWE, Secretary.

Paper by Dr. W. A. Briggs.

General Lewellyn Tozer, Chairman of the Sacramento Citizens' Water Committee.

Dear Sir: Permit me to say that I found it impossible to act with your Committee, and so informed the Honorable Mayor in declining the appointment, received late in the course of your investigations. Not having participated in your labors, I felt that to join in your report would put both the Committee and myself in a false position. It was respect for your Committee and its painstaking work, I assure you, and not intended discourtesy that withheld my signature. Not by any means that I have no opinion on this question so vital to all, for, on the contrary, I have an opinion derived, I believe, from a thorough and comprehensive study of the facts, analogies, conditions and principles involved. With your permission I shall embrace this opportunity to express it fully and yet, if possible, not too much at length.

1. In the long run the well supply, in my opinion, will be more reliable than the river supply. By deforestation of the mountains, mining, irrigation and electric-power plants the American has been impoverished almost to the last degree—at least, judging from the prompt threat of injunction that met a recent proposal to supply the city of Sacramento from this source. The same process of deforestation, the same appropriation of water for mining, irrigation and power occur on the Sacramento and its tributaries and are producing the same results. Greater enterprises are now projected and still greater ones will assuredly be consummated in the not distant future. For what observant Californian doubts that the Sacramento Valley is destined soon to be covered by a vast carpet of luxuriant vegetation, and chiefly by virtue of the waters of its principal river? What then will have become of the "inexhaustible" Sacramento? It will have followed the "inexhaustible" American. Even to-day it is but the shade of its former self. The truth is that the present generation will demonstrate that, for municipal purposes, our subterranean streams are more truly inexhaustible than our great rivers, for the demands on the former, except for domestic and municipal use, will materially diminish, while, on the contrary, the demands on the latter will enormously increase.

2. Hand in hand with this diminishing volume of our rivers will go just as certainly a correspondingly increasing population using the river channels for drainage. In this magnificent valley other Sacramentoes will arise, and, emulating, perhaps, our own punctillious regard for decency and law, will discharge their sewage into the rivers. Factories will come and who, but a "silurian," will dare deny them any

factory? Cattle will multiply on a million acres if not on a thousand hills. All these, with the decaying vegetation inevitably following intensive agriculture, will foul the lands drained by the Sacramento and its tributaries and will further pollute their waters. Rivers, in fact, have been called Nature's sewers, and so they are.

What does this diminishing flow of water and increasing content of filth portend? When the city of Sacramento shall celebrate its centennial, if not before, we may not unreasonably predict that, in the dry season, the Sacramento will be reduced to one-fifth of its present volume and will carry five fold its present content of filth. That is, its pollution will be twenty-five times as great as now. If filters should remove 98 per cent. of this filth there would still remain 50 per cent. as much as our present unfiltered supply contains; and if only 90 per cent., there would yet remain 250 per cent., or two and one-half times as much as the present pollution. But with increasing pollution, filters fall in efficiency, and I doubt very much if, in forty years, they would furnish water really as potable as our present unfiltered, and, I hope, soon to be unlamented, river supply.

3. It is wise for a city no less than for an individual to count the cost. The economy of the subterranean supply is manifest. The initial expense is confessedly less than that of the filtration scheme by some $50,000 or $100,000. The annual saving in expense of operation, etc., is variously estimated at from $15,000 to $22,000—the interest on approximately a half million dollars. In other words in the long run the filtered river supply would cost a half million more than the subterranean supply—a sum certainly not insignificant even when levied on the affluent; and, when pinched, penny by penny, from the pockets of the toiling multitude, it becomes positively monumental. But by no means is this the only economy, perhaps by no means the greatest economy, of the proposed subterranean supply, even from a purely financial standpoint. The well supply would save materially in the expense of disease and death. It would effect a still higher economy, from a physician's point of view, the one imperative economy—an economy in health and life. Let us count the cost.

4. The well plant would possess the important desideratum of simplicity in a much higher degree than the filtration system. It would be far more comprehensible and more manageable by the official intelligence.

5. In installation and management the filtration system would lend itself more easily to official corruption; it would afford greater patronage to the boss, greater opportunity for jobbing of one kind and

This report, therefore, refers exclusively to the proposed improvements in the city pipe system.

On arriving in Sacramento my first step was to obtain a good map, showing the location and sizes of the existing distributing mains. This was furnished to me by Mr. T. B. Hall. I then proceeded to City Engineer's office, where I met Mr. Watt, the pipe chief, and he and I compared the map in hand with the standard maps on record to ascertain whether the Hall map correctly represented the existing pipe system. It was finally concluded that it was correct and reliable.

A study of the existing pipe system developed the following facts:

First—The pumping works are now located at the corner of Front and I Streets. The pipe system begins here with a 20-inch riveted main, extends easterly along I Street, diminishing to 18 inches, and reaching as far east as Ninth Street, thence turns south along Ninth Street as far as the south line of K Street. This riveted pipe was made and laid in 1873, and is now twenty-eight years old. If properly made and coated, this pipe ought to be good for twelve years' service yet. At this point the 18-inch riveted connects with a reducer to a 14-inch cast, which continues southerly to the alley line between N and O, where it connects with a reducer to a 12-inch cast, which continues southerly to the alley line between P and Q, where it connects with a reducer to a 10-inch cast, which, continuing south, terminates in a dead-end at the south line of Q Street.

BRANCH MAINS.

First—A 16-inch riveted branch main begins at the intersection of Ninth and I Streets, thence easterly along I to Sixteenth Street, thence south along Sixteenth Street to the south line of L, where it connects with a reducer to a 12-inch cast. This riveted pipe was made and laid in 1880, and is, therefore, in all probability, good for nineteen years' service yet. Thence the 12-inch cast extends south and terminates in a dead-end at the north line of P Street.

Second—A smaller branch 13-inch cast begins at the intersection of Second and I Streets, thence extends south along Second to the alley line between M and N Streets, where it connects with a reducer to a 12-inch cast, which extends south to the alley line between N and O Streets, where it connects with a 6-inch cast alley main.

SMALL ALLEY MAINS.

The large mains above described constitute all the chief arterial pipes in the entire city. The balance of the pipes are nearly all small sizes—8-inch, 6-inch, 4-inch cast and 3-inch and 2-inch wrought.

The characteristic feature is that these small mains, with rare exception, do not follow the streets, but pass through the alleyways, situated midway the blocks, and have an easterly and westerly direction. The chief cause of complaint undoubtedly arises from the extraordinarily abnormal length of small mains, without any cross-connecting mains of any kind whatsoever. Some of these 6-inch cast alley mains are fourteen and fifteen blocks long, and a large percentage are ten blocks long, without a single cross-connection, and as a rule all terminating in dead-ends. These facts show clearly the proper remedy is the introduction of a good system of larger mains, 10-inch, 12-inch and 14-inch cast, intersecting the existing system of small alley mains at right angles so as to cut them up into shorter lengths of, say; three and four blocks only. Such a system has been designed and a new city water pipe map is now in preparation under my direction which will remedy the evils complained of and furnish excellent pressure, with good, efficient fire hydrant service.

It is highly desirable to submit two schemes and estimates for the improved pipe system, namely, one embracing the entire city of Sacramento out to the extreme city limits, with due provision for easterly extensions; the other embracing only such portions of the general scheme as may be deemed necessary to meet all present requirements, and which will make use of the existing riveted pipe until their natural life of usefulness has expired.

GENERAL SCHEME FOR CITY PIPE SYSTEM.

The full details of the proposed general distributing system will be seen by reference to the map now in course of preparation. In general terms it may be described as follows: The 20-inch cast mains will embrace a large rectangle represented by I and Q Streets on the north and south and by Sixth and Twenty-eighth Streets on the west and east. At the southeast and northwest corners of the rectangle a larger 28-inch riveted supply main will be necessary, either extending easterly towards the proposed East Side Wells pumping station or westerly along I Street to Front, and thence northerly to the site of the proposed filters and pumping station located near the west end of the north levee. This is not included in the estimate, because undecided. These large mains will constitute the chief arterial pipes for general distribution. From these a system of branch mains extend both northerly, southerly, easterly and westerly, dividing the city into small rectangles of, say, three, four and five blocks on a side; but the general aim should be to intersect the small alley mains so as to sub-divide them into short lengths not to exceed four blocks in length, and no dead-ends if possible.

ESTIMATE OF COST OF GENERAL SCHEME.

20-inch cast, 24,550 feet, at $4	98,200
16-inch cast, 400 feet, at $3.20	1,280
14-inch cast, 21,600 feet, at $2.80	60,480
12-inch cast, 66,650 feet, at $2.31	153,961
10-inch cast, 46,800 feet, at $1.86	87,048
160,000 feet (nearly 30 miles)	$400,969

The above rates per foot linear includes specials and paving.

NEW GATES.

10-inch gates, 63 at $38	$2,394
12-inch gates, 100 at $47	4,700
14-inch gates, 26 at $60	1,560
16-inch gates, 3 at $137	411
20-inch gates, 34 at $155	5,270
Total	$14,335

Note.—Prices include boxes only for sizes below 16-inch, setting being included in the pipe laying.

PARTIAL SCHEME TO MEET PRESENT DAY REQUIREMENTS.

After studying the existing pipe system and its lack of efficiency, I have come to the following conclusions as to the best method to adopt in relieving the existing troubles.

Full details of the proposed partial scheme for re-enforcing the existing pipe system will be seen by reference to the special map now in course of preparation.

ESTIMATE OF COST OF PARTIAL SCHEME TO MEET PRESENT DAY REQUIREMENTS.

NEW PIPE.

20-inch cast, 20,500 feet, at $4	$82,200
16-inch cast, 400 feet, at $3.20	1,280
14-inch cast, 5700 feet, at $2.80	15,960
12-inch cast, 10,900 feet, at $2.31	25,179
Total	$124,619

Note.—The above rates per foot linear includes special castings and paving.

NEW GATES.

20-inch, 22, at $155	$3,410
16-inch, 2, at $137	274
14-inch, 5, at $60	300
12-inch, 13, at $47	611
Total	$4,595

Note.—Price includes boxes only for sizes below 16-inch, setting being included in pipe laying.

FINAL REMARKS.

In conclusion, I would respectfully call your attention to the great financial importance of a good pipe system and efficient fire hydrant service.

Good fire hydrant service demands 150 feet net pressure in densely built portions of city, while the suburbs should have at least 100 feet net.

Experience all over the Union shows that by the introduction of water works with good pipe systems the average annual loss by fire becomes only one-sixth of the former losses. In a large number of instances the annual savings amount to $125,000, and in five to six years fully cover the entire cost of the water supply.

As to fire insurance rates, we find that the financial value of enhanced fire risk and additional premium charged on the most favorable buildings is 60 per cent without water works and 40 per cent if only fire cisterns are provided, and still less for more extended improvements. The perpetual reduction in rates is a matter of great and lasting value to any community. Respectfully submitted,

L. J. LE CONTE, C. E., M. Am. Soc. C. E.

P. S.—My attention has been called to an unusual omission in the old pipe system, which is not open to inspection. I refer to the general absence of auxiliary gates to hydrants—consequently when repairs become necessary the street supply has to be cut off. This should not be allowed to continue. Mr. Watt informs me that there are 424 such 4-inch hydrant branches without 4-inch gates. They are cheap, single disc gates and only cost $8 to $10 each. I would recommend that these gates be put in at your convenience. L. J. L.

Statement of Expenditures.

Since the organization of the Committee, forty-three sessions have been held. Much of the work, however, was done at sub-committee meetings and by individual members, many of whom visited cities throughout the East and in this State, in search for information upon the water question at their own expense.

The following is a general statement of the amount expended by the Committee, vouchers for which are on file with the City Auditor:

Committee on Wells	$ 6,573 73
Committee on American River Supply	50 76
Committee on Sacramento River Supply	500 00
Committee No. 4	517 20
Committee on Analyses	311 65
General Committee	2,186 70
Total	$10,140 04

625.1

Report of the Citizens' Committee Appointed by the Chamber of Commerce of

SACRAMENTO
THE
♥
OF
CALIFORNIA

To Investigate all Sources of Pure Water Supply

Rendered June 28, 1913

Report of the Citizens' Committee Appointed by the Chamber of Commerce of the City of Sacramento to Investigate all Sources of Water Supply

Rendered June 28, 1913

Citizens' Pure Water Committee

F. B. McKEVITT, Chairman

MRS. WM. BECKMAN
MRS. C. E. McLAUGLIN
MRS. J. J. C. FITZGERALD
MRS. A. M. SEYMOUR
DR. W. E. BRIGGS
F. A. EDINGER
M. F. SHELLEY
HERMAN DAVIS
J. L. GILLIS
F. H. REYNOLDS
S. W. DOWNEY
GEO. C. BASSETT
ALFRED DALTON, JR.
DR. F. F. GUNDRUM

Report of Committee

Sacramento, Cal., June 28, 1913.

To the Chamber of Commerce of Sacramento,
Sacramento, California.

Gentlemen:

Your committee appointed April 13, 1912, to investigate water supply of the City of Sacramento begs leave to report as follows:

Said committee after appointment commenced an investigation of water supply of the City of Sacramento, and after careful study of the various sources of supply, to-wit, well water, mountain water and river water, does hereby recommend that the City continue to utilize the Sacramento River as a source of supply, and that the water be subjected to some such method of purification as is outlined in the report of the sub-committee on Sacramento River water herewith filed.

Your committee further recommends that the City Commission of the City of Sacramento take such steps as may be necessary to secure a proper site for filter beds and for the construction of a filteration plant.

Herewith your committee files as supplementary to this report the reports of its sub-committees, to-wit: Mountain Water Supply, Well Water Supply, and Sacramento River Supply.

Respectfully submitted,
S. W. DOWNEY,
Secretary.

WELL SUPPLY.

To the Citizens' Water Investigation Committee,
City of Sacramento, Cal.

At the outset of our investigations it became obvious that in order to secure data that would enable your committee definitely to recommend or definitely to condemn the use of wells as a source of supply for the City of Sacramento, your committee would need funds.

The services of an engineer competent to make survey of the channels and ground waters underlying the City and its suburbs, the purchase of boring privileges from land owners, the purchase or hire of machinery, the employment of well borers may all be considered necessary to the acquisition of data upon which to base a reliable report.

No funds being available for the purpose, your committee has confined itself to inquiry into the history of previous investigations made with objects similar to that for which your committee was appointed, to the recommendations made by other investigators of the subject, and to the discovery of those later evidences which might serve to prove or disprove the recommendations of prior investigators.

Your committee finds that in [illegible] the Sacramento Chamber of Commerce tested a number of wells and reported the existence of an underground flow of water of great quantity and good quality.

In January, [illegible], under the direction of a then existent Citizens' Committee on Wells, a survey of the ground water was begun by L. J. Le Conte, C. E. and resumed in January, [illegible].

The result of that survey and of the collateral inquiry pursued by the Citizens Committee indicated that a flow of at least [illegible] gallons daily could be obtained. The City was then using 6,[illegible] gallons daily.

It was reported also that the cost of installing such a system as the City needed would not exceed $[illegible].

The Committee on Analyses, or Purity Committee as it was styled, reported that the well water obtained during the survey was suitable alike for domestic and manufacturing purposes, and absolutely free from bacteria and organic matter.

This Committee on Analyses, in comparing filtered river water with that obtained from wells, declared itself of opinion that the well supply would prove the more constant or uniform in quality.

During the investigations referred to a report on the possible sources of supply was obtained from Rudolph Hering of New York, an engineer of high standing and wide experience.

His report strongly endorsed the wells as the best of the water supply projects then under consideration.

Your committee has made investigation of the well water supplies which have been developed during the thirteen years which have elapsed since the filing of the reports mentioned. Your committee finds that such developments are numerous and extensive, and are generally confirmative of the opinions expressed in the before mentioned reports to the effect that a large ground supply of good water exists in Sacramento. Your committee finds, in fact, that a considerable portion of the City is excellently served by a water company which operates a well system, and the large number of private wells in existence seem to be yielding abundant supplies of good water to their owners.

The experience of Buda Pesth (600,000), Munich (400,000), Brussels (500,000), Dresden (300,000), and the city of Brooklyn (partial supply) proves that in cities where an adequate supply of good ground water exists, a satisfactory service of such water can be made therein.

Your committee finds:

(1) There is strong indication that a body of ground water large enough adequately to supply the City's needs exists in Sacramento.

(2) That such water is of excellent and uniform quality, free from bacteria and organic matter, and completely suitable for domestic and manufacturing purposes.

(3) The estimated cost of installing such a system of wells seems to be less than the estimated cost of the other systems of water supply which, at various periods, have been submitted to the City.

(4) The estimated cost of maintaining a system of wells is less than the estimated cost of other systems.

(5) The cost of later extension of a system of wells apparently would be less than the cost of extending the other proposed systems.

Since the data studied by this committee seems to prove that the well system, in comparison with other proposed systems, costs less to install, less to maintain and less to extend than other proposed systems, and seems also to prove that such system of wells can be relied upon to yield an adequate and constant supply of good water, your committee advises the General Committee that in the selection of a suitable water supply for the City of Sacramento, any proposal to utilize the ground water by means of a system of wells should be given the most careful and thorough consideration, with a view of determining once and for all the adequacy or otherwise of the well system to supply the domestic and commercial water needs of our rapidly growing city.

Respectfully submitted,

WM. ELLERY BRIGGS,
Chairman.
HERMAN DAVIS,
Secretary.
F. B. McKEVITT,
GEO. C. BASSETT.

MOUNTAIN SUPPLY.

Mr. F. B. McKevitt,
Chairman of the Sacramento Chamber of Commerce Water Committee, Sacramento, Cal.

Sir:

Your sub-committee appointed to investigate a possible mountain water supply begs leave to report as follows:

(1) Method of investigation.

The files of the daily newspapers published in Sacramento were searched from January 1, 1901, to date. Letters were addressed to all persons or corporations whose names appeared in said papers, offering to supply the City with water derived from mountain sources. Correspondence was entered into with persons and corporations making application to the committee for opportunity to submit propositions for a supply of mountain water.

Your committee being unsupplied with funds necessary to furnish itself with legal counsel or the services of a field engineer, the validity of water rights, options, holdings, etc., as well as the authenticity of maps, watersheds, estimates, etc., must be considered subject to further investigation. All figures presented in the report depend entirely upon descriptions supplied your committee by parties submitting proposed water supplies for our consideration. We have, however, as far as possible, verified all material submitted to us through the use of Geological Survey maps, and more especially through the kindness of Mr. John F. Armstrong, Director of the United States Land Office, to whose thorough-going knowledge of the subject and never failing interest in the water problem your committee takes this opportunity of expressing its grateful appreciation.

The following individuals and corporations with whom your committee began correspondence expressed unwillingness to offer water supply propositions to Sacramento:

(1) North Fork Ditch Co.
(2) California Corporation.
(3) Natomas Consolidated.
(4) R. L. Dunne.
(5) Mt. Shasta or McCloud River Project.
(6) J. J. Crawford (Diamond Ridge Ditch.)

We have endeavored to tabulate each of the several propositions considered by us under the following heads:

(1) Name of Company or Project.
(2) Date of Proposal.

(3) Source of Supply.
(4) Conduits.
(5) Available Amount of Water.
(6) Pressure at Sacramento.
(7) Total Cost to Sacramento.
(8) Contamination.

Following the details of each proposed supply, your committee has set forth its conclusions regarding that supply.

I

(1) Name—
    United Power & Water Co.
(2) Date—
    March 22, 1912.
(3) Sources—
    Yuba, Bear and North Fork of American River.
(4) Conduits—
    Earth and rock ditch, wooden flumes, stream beds of Bear and North Fork of American Rivers, concrete pipes.
(5) Water—
    100 million gallons per day.
(6) Pressure—
    60 pounds per square inch.
(7) Total cost—
    $2,000,000 to $3,000,000.
(8) Contamination—
    Townsite of Cisco on Yuba.
    Townsite of Dutch Flat on canal.
    Mining and habitations on North Fork or American.
    Colfax sewage.

In the opinion of your committee this supply is unavailable on account of the great and apparently uncontrollable contamination to which this water is subjected.

II.

(1) Name—
    James O'Brien, Plymouth, Cal.
(2) Date—
    May, 5, 1912.
(3) Sources—
    Cosumnes River
(4) Conduits—
    Not specified.

(5) Water amount—
Not specified.
(6) Pressure—
Not specified.
(7) Total cost—
Not specified.
$80,000 asked for dam site and water right to 40,000 inches.
(8) Contamination—
Grizzly Flat, Caldor, El Dorado townsite, Mother Lode mines in watershed and reservoir site.

In the opinion of your committee this proposition is not available in the form submitted, first, on account of numerous sources of contamination in the watershed; second, on account of the presence of gold mines in the shed and reservoir sites making the acquiring of said watersheds and dam a proceeding of great expense to the City. Consideration of this project is necessarily incomplete on account of meagerness of data supplied.

III.

(1) Name—
Sacramento and Sierra Water & Power Co.
(2) Date—
May 11, 1912.
(3) Sources—
Panther, E. Panther, Tiger, Mill and Antelope Creeks (tributaries of the Mokelumne River), Sutter Creek and tributaries.
(4) Conduits—
Creek bed (Sutter Creek) 5 miles, pipe lines 50 miles.
(5) Amount of water—
20,000,000 gallons or more per 24 hours.
(6) Pressure—
85 pounds per square inch.
(7) Total cost—
$2,500,000.
(8) Contamination—
Extremely slight—from cattle grazing only.

In the opinion of your committee this company offers an unusually pure water, under adequate control and at a reasonable price. It is open, however, to the possible objection that the total amount of water available is not sufficient for the needs of the City in future years.

IV.

(1) Name—
    Messrs. Scribner, Bills & Patton.
(2) Date—
    December 16, 1912.
(3) Source—
    Middle Fork Cosumnes River.
(4) Conduits—
    Rock canal, tunnel, pipe line.
(5) Amount of water—
    40,000,000 gallons per 24 hours.
(6) Pressure—
    100 pounds per square inch.
(7) Total cost to Sacramento—
    $7,000,000, or will sell present rights for $500,000.
(8) Contamination—
    Habitations above dam site. Sawmill at Dogtown Gulch. Slug Gulch. Crystal and Independence mines.

In the opinion of your committee the contamination present in this watershed is capable of abatement at comparatively little expense, and does not constitute a valid objection to the consideration of the proposition of Messrs. Scribner, Bills & Patton. The cost, however, appears to be greater than the City of Sacramento can well afford. The recent addition to our bonded indebtedness necessary for other purposes has so increased the City's liabilities that a further increase of our debt by $7,000,000 would carry the sum well beyond a conservative debt for a City of our size. The purchase of the water right and options held by the gentlemen would in no particularwise nullify this objection, for, not only would the City be obliged to expend a certain and considerable sum yearly to maintain and perpetuate said rights, but it must ultimately incur the expense of completing said system, i. e., $7,000,000 or thereabouts.

VI.

(1) Name—
    J. H. Hoyle et al.
(2) Date—
    March 28, 1913.
(3) Source—
    Middle and South Forks of Cosumnes River.
(4) Conduits—
    Canals, flumes, pipes.

(5) Amount of water—
    64,000,000 gallons per 24 hours.
(6) Pressure—
    200 pounds, more or less, as specified later.
(7) Total cost—
    $2,500,000.
(8) Contamination—
    Ranches and habitations.

In the opinion of your committee, upon superficial examination, this proposition seems to undertake to furnish an apparently clean water supply adequate in amount and at a reasonable total cost. Further investigation of this supply seems to us to be advisable.

(1) Name—
    Cosumnes Irrigation Project. E. R. Walker.
(2) Date—
    April 10, 1913.
(3) Source of supply—
    Middle Fork of Cosumnes River.
(4) Conduits—
    Ditches, flumes and pipe lines.
(5) Amount of water—
    40,000,000 gallons per 24 hours.
(6) Pressure—
    Not specified.
(7) Total cost—
    Not specified. Will sell water rights, options and contracts for $565,000.
(8) Contaminations—
    Habitations above damsite. Sawmill at Dogtown Gulch. Slug Gulch, Crystal and Independence mines.

The storage reservoir site, damsite and reservoir offered by Mr. Walker in this project are the same as those presented for our consideration by Messrs. Scribner, Bills & Patton. The contamination, as hereinbefore mentioned, is capable of abatement at reasonable cost. The sum asked for water rights, options, contracts, etc., is comparable to that demanded in project No. IV. There is no sum mentioned as a total cost, but it is not unreasonable to suppose that this cost will at least, in considerable measure, approximate the one mentioned in said project No. IV, i. e., $7,000,000.

In the opinion of your committee the chief objection to this proposition is the same as that to proposition No. IV, i. e., the great total cost of the system.

Your sub-committee regrets exceedingly the very long delay in presenting this report. The delay was, in a large measure, occasioned by the anxiety of the members of said committee to include, if possible, all available sources of mountain water. The presentation of our report has, therefore, been postponed from time to time to allow one after another proposition to be laid before your committee.

Engineer's reports received containing detail estimates of cost of constructing water systems, together with descriptions of water rights, options, reservoir sites, dams, conduits, etc., have been kept on file by the committee.

Respectfully submitted,
SUB-COMMITTEE ON MOUNTAIN WATER SUPPLY.
DR. F. F. GUNDRUM,
Chairman,
MRS. W. M. BECKMAN,
MRS. J. J. C. FITZGERALD,
F. A. EDINGER,
FRANK H. REYNOLDS,
Secretary.

FILTRATION SUPPLY.

A REPORT UPON THE PURIFICATION OF SACRAMENTO RIVER WATER FOR THE SUPPLY OF THE CITY OF SACRAMENTO, CALIFORNIA.

By a Sub-Committee of the Special Water Committee of the Chamber of Commerce.

Mr. F. B. McKevitt, Chairman,
Special Water Committee Chamber of Commerce,
Sacramento, California.

Sir:

Your sub-committee on the use of Sacramento River water, after purification, for the supply of the City of Sacramento, begs to state that it has given careful consideration to this whole matter and desires to submit the following brief report:

Brief History of Works.

In 1848 the site of the City of Sacramento was virtually uninhabited. In 1850 the Federal census revealed a rapidly growing community of upwards of 6800 persons. From 1849-'50 to 1854 a meager supply of water was furnished to the inhabitants of the town through private enterprise. The supply was derived from the Sacramento River by means of crude pumping engines erected directly on the bank of the stream. These pumps delivered the water into storage tanks from which it was taken in tank carts which were hauled about the town and from which the water was peddled in very much the same manner that milk is today.

In 1854 the community began for itself the construction of a system of public water works. The source of supply was still the Sacramento River, taken from the east bank of the stream near the foot of J and I Streets, which source has been continued in use to the present time. The first pumps were erected near the foot of J Street. Before long these proved inadequate and unsatisfactory, and after almost endless discussions and delays, finally, in 1874, a new pumping plant was erected at the present site at the foot of I Street. From time to time the station building has been enlarged and new and better equipment has been added. The present pumping equipment comprises four pumps of various types and efficiencies aggregating a nominal daily capacity of twenty-three million gallons, and four safety water-tube boilers having a total capacity of 600-horsepower. At least two of the pumping units recently in use were of a type entirely unsuited to the conditions which obtain, and the city is now facing the problem of providing a suitable and up-to-date pumping station, with adequate and satisfactory equipment. The present building, erected in 1874 and occasionally enlarged, is not to be regarded as an architectural triumph, and certainly reflects no particular credit to the city. In the proposed new scheme of works, a beautiful new pumping station would be provided with new and up-to-date machinery, supplemented by that part of the present equipment which is of such character that it may properly be made use of. The present site could be used for other public purposes, perhaps best for a water works pipe and supply yard, with shops, etc., with which every up to date and well managed water works system should be provided.

In the early history of the works the water of the Sacramento River was clear, bright in appearance and thoroughly satisfactory. But with the advent of hydraulic mining the stream soon became excessively turbid and unsightly, and this condition still prevails, unfortunately, throughout the major portion of each year. During the last few years, however, since hydraulic mining operations have been largely controlled by the California Debris Commission, a decided improvement in the condition of the stream has been produced. To illustrate the significance of these long-continued mining operations upon the stream, it is only necessary to state that the Debris Commission estimated in 1909 that the deposits in the Feather and American Rivers alone still amounted to fully 500,000,000 cubic yards, notwithstanding that vast quantities of material have in past years been washed down into the Sacramento River and thence into Suisun, San Pablo and San Francisco Bays.

Due to the unsatisfactory appearance of the water produced in this way the Sacramento River supply came to be generally regarded as unsatisfactory, and various more or less diligent inquiries were made from time to time by the city authorities and by private parties into other possible sources of supply or means of improving the one in use. Of these investigations the most notable and painstaking were those made in 1899-1901 by the Citizens' Water Investigation Committee, and in 1898-'09 by the Water Committee of the Board of Trustees, especially Messrs. Carraghar and Rider and the City Engineer, Mr. George F. Randle. The investigations of 1899-1901 were concerned with a consideration of all possible sources of supply, but after a complete review of the situation only two sources were found to be worthy of serious consideration, if undertaken as an independent supply for the City of Sacramento without co-operation with other large cities. These feasible sources were the Sacramento River, with suitable purification, and a ground or well water supply to be obtained from the territory lying southeast of the City at a general distance of about 2.75 miles from the State Capitol. The majority of the committee favored the filtered water supply from the Sacramento River. The investigation of 1908-'09 was mainly concerned with a careful consideration of the feasibility, propriety, efficiency and cost of the purification of the water of the Sacramento River and with the selection of the most suitable point of intake and location of works. In March, 1909, Professor C. G. Hyde of Berkeley was engaged to investigate the project of purifying the supply of water derived from Sacramento River, and to report upon feasible methods and costs. After a six months' study of the matter, Mr. Hyde submitted a detailed and comprehensive report covering all phases of the purification problem. Upon the basis of this report a bond election was called but failed to carry by a few votes. A second attempt to vote bonds failed by a much larger margin.

Public vs. Private Ownership of Water Works.

A review of the water works history of the United States shows clearly and unmistakably that for many years the trend has been toward public rather than private ownership of works. In 1800, of the sixteen water works then in existence, only one was municipally owned; in 1850 municipal ownership had extended to about 40 per cent of the 90-100 plants constructed up to that time; in 1900 60 per cent of all systems of water works in the United States were publicly owned. At the present time it is estimated that from 70 to 80 per cent of all existing water works are owned by the municipalities in which they are located.

In 1902, in cities of the United States having by the census of 1900 populations of 30,000 and over, fully 71 per cent of all water works systems were municipally owned. In the fifty largest cities of the United States, as determined by the census of 1900, only nine water works, or 18 per cent of the total number, are now privately owned. In other words, forty-one places, or 82 per cent, own and operate their water works systems. In several of these places where private ownership still prevails, public ownership has been earnestly advocated, and in certain of these, for instance San Francisco, such action seems about to be consummated.

Recently in Sacramento effort has been made to place before the voters for consideration certain water supply propositions wherein is involved the purchase of water from private parties. Usually, under these propositions, the city is to become merely the distributer and retailer of water, and all rights and control of sources, including drainage basins, reservoirs, main canals, etc., would remain with the private parties who contract as wholesalers of water. If such contracts were made for a definite period, it is evident that grave difficulties might arise when renewals become necessary unless the terms of purchase are definitely stated for all time, which on many grounds would be undesirable and illogical. In such cases, with the increased demand for water for other purposes, such as irrigation, it would be only natural that the price would rise from time to time and the cost eventually become very exorbitant.

Such propositions, if considered at all, should be studied with great care and deliberation, and should receive the endorsement and recommendation of an unbiased and disinterested board of experts.

The water works of Sacramento are now and always have been owned and operated by the City as a municipal undertaking. This control has extended to the source of supply, namely the Sacramento River opposite the city, insofar as the acquirement of vested water rights and the protection of its intake, etc., are concerned. These rights are indisputable, and no one has ever suggested that the time would come when this mighty stream would or could be reduced in volume of flow to such a point as would be insufficient to meet the ultimate needs of the City. These rights have cost and will continue to cost the City nothing.

Having for so long a time had complete control over its entire system of works, from the source of supply to the point of delivery to consumers, it is scarcely to be anticipated that the people of Sacramento would be willing to adopt a new source over which they could not exercise complete ownership and control.

Present Water Consumption and Necessary Future Capacity of Works.

At the present time the per capita use of water in Sacramento is relatively very large. It is estimated that during the current year the average daily per capita consumption will be as much as 300 gallons, giving a total average daily consumption of 15,000,000 gallons for the entire City. Looking to the future and basing judgment upon probable population development and upon past and present water supply requiriments, it would appear that by 1950 the average daily consumption will have risen to at least 25,000,000 gallons and possibly to 45,000,000 gallons, if the present excessive rate of waste of water is continued. In 1950 the maximum day's use may be anywhere from 35,000,000 gallons to 60,000,000 gallons, depending upon whether the water supply is conserved or is grossly wasted.

From these figures it is to be concluded that no source should seriously be considered for the future water supply of Sacramento which cannot be made to yield a maximum supply of at least 30,000,000 gallons at the first stage of development, 60,000,000 gallons by 1950, if necessary, and ultimately a very much larger quantity, for it may be accepted as a fact that Sacramento will eventually become a very large city. It is difficult to state what maximum quantity of water should in the distant future become available from any source of supply adopted at the present time to meet the current requirements and those of the not remote future. Perhaps a conservative figure would be at least as great as 100,000,000 gallons, while 200,000,000 gallons could scarcely be considered unreasonable.

The Sacramento River as a Source of Supply.

The Sacramento River is by very far the largest stream in California. The drainage area tributary to the river above the City of Sacramento is estimated to embrace upwards of 26,000 square miles. The minimum dry weather flow, just below the mouth of the

American River is probably about 6000 cubic feet per second, or about 4,000,000,000 gallons per day. The ordinary dry weather flow is perhaps 8000-10,000 cubic feet per second, and the average flow of an ordinary year possibly 30,000-40,000 cubic feet per second. The maximum flood discharge, if confined to the main channel passing Sacramento, has been estimated to be nearly 560,000 cubic feet per second. The minimum flow will, in all probability, always be so great that no consideration will ever require to be given to the adequacy of the supply derived from this source.

The population living within the drainage basin of the river above Sacramento is now very sparse, amounting to less than 6.5 persons per square mile. Only a very small proportion of this population lives in towns provided with sewerage systems. In 1950, it is estimated that the population per square mile may be between 11 and 14.

At the present time, therefore, the stream is polluted only slightly with sewage. But the amount of sewage contamination is sufficient to exercise a real effect upon the prevalence of typhoid fever among those drinking the water and quite sufficient to justify the necessary expenditure for purification works. On the other hand, the degree of contamination is not now and never will be so great as to render purification difficult or uncertain. The laws of this State protecting the purity of inland waters are sweepingly severe, and it is safe to say that in the future they will be rigidly enforced, and that the water of the stream will always be much better than that of the Alleghany, Delaware, Hudson, Merrimac, Mississippi, Ohio, Potomac, Schuylkill, Scioto, Susquehanna and other rivers which today are being so successfully purified for water supply purposes in the cities of Pittsburgh, Pa.; Philadelphia, Pa.; Albany, N. Y.; Lawrence, Mass.; New Orleans, La.; Cincinnati, Ohio; Louisville, Ky.; Washington, D. C.; Columubs, Ohio; Harrisburg, Pa., and many other places too numerous to mention.

The water of the Sacramento River is always somewhat turbid, and during flood season and at times when dredging operations are being conducted in the river or its tributaries is exceedingly muddy. The water seldom has a disagreeable odor when cold, but when hot a rather pronounced odor, sometimes slightly objectionable, is to be observed. The river is not subject to growth of micro-organisms, such as the algas. The river water is relatively very soft; indeed, it furnishes one of the softest supplies in California, the total hardness being only a fraction of the hardness of the supplies of such cities as Alameda, Berkeley, Fresno, Los Angeles, Oakland, Pasadena, Richmond, San Diego, San Francisco, Stockton and various other cities of the State.

A careful study of the results of analyses of samples of water collected to represent all stages and conditions in the stream during 1909 show conclusively that the Sacramento River water may be readily treated by the particular purification process recommended by Mr. Hyde, and that no fear need be entertained with respect to the reliability or satisfactory quality of the effulient of these works, if properly built and operated.

Extracts From Special Discussion of Purification Project Prepared by Mr. Hyde.

In order that certain specially important features of the project proposed by Mr. Hyde in 1909 for the purification of Sacramento River water for the supply of the City of Sacramento may become known to the members of the entire committee, the following extracts have been taken from a special paper discussing the project as prepared by Mr. Hyde.

Proposed Type of Works.

During the past twenty-two years most comprehensive studies of various possible methods of purification of all types of natural waters have been conducted at various points in the United States. Such investigations, in order of their inception, have been conducted at Lawrence, Mass., on the Merrimac River; East Providence, R. I., on the Pawtuket; Louisville, Ky., and Cincinnati, Ohio, on the Ohio River; Pittsburgh, Pa., on the Alleghany Rivers; Washington, D. C., on the Potomac; Philadelphia, Pa., on the Delaware and Schuylkill Rivers; Harrisburg, Pa., on the Susquehanna River; New Orleans, La., and St. Louis, Mo., on the Mississippi River, and at various other places. Purification plants at all of these places have been constructed, and the results of laboratory experiments have been confirmed and elaborated. Today in the United States slow sand filtration plants are operating to supply upwards of 3,000,000 persons, and rapid sand plants upwards of 6,000,000 persons. Moreover, preliminary or preparation processes have been developed, in connection with these different types of final treatment, to a high degree of efficiency and with great certainty of operation. For many years the writer has been closely in touch with these investigations, and is familiar with the conditions under which the various processes of purification may be made to operate most successfully.

In his report to the Special Water Committee of the Board of Trustees, the writer outlined four possible schemes or systems of purification, any one of which could be made to give satisfactory results if properly designed, constructed and operated. These schemes were mutually compared on the basis of general cost, reliability, flexibility and usual or normal efficiency.

Holding in review the entire situation, including both local and general conditions, a system of purification processes for Sacramento has been advised which may be briefly outlined as follows:

(a) **Preliminary subsidence** in a grit basin to remove the coarsest sediment which would settle rapidly and freely, due to its own weight and character.

(b) **Further and prolonged subsidence,** employing a coagulant when necessary, to remove the great bulk of finer suspended matter and a significant percentage of bacteria.

(c) **Final purification through rapid filters** of the latest type, employing a secondary dose of coagulant applied in specially designed basins containing a sufficient storage merely to permit the chemical reaction to take place and insure a well-defined flocculation of the water.

(d) **Sterilization** to remove the last traces of bacterial life and serve as an additional safeguard, rendering the water as pure and safe, or safer than could be produced in any other possible way or from any other possible source. This result would be secured with the use of minute quantities of a powerful oxidizing agent known as calcium hypochlorite.

The system above outlined will compare most favorably, in point of cost of construction, in annual costs, in flexibility and reliability, in the required space for present works and for future extensions, with any other scheme which can be devised with our present knowledge of the science and art of water purification.

Proposed Site of Works.

The local conditions are such that no very wide opportunity for a choice of location for the proposed filtration and pumping works is offered. The tract proposed embraces some 29.4 acres (measured to the well defined present bank line), situated on the east bank of the Sacramento River and immediately north of the levee at the north side of the Southern Pacific Railroad yards. It was selected for the filter plant by the City Engineer and members of the Special Water Committee of the Board of Trustees, and is exceedingly well adapted to the purpose in view. It is of sufficient size to admit of indefinite future extension of works of the type recommended by the writer.

Brief Outline and Description of Works.

In preparing the general layout and the more important details of the proposed system of filtration and pumping works for the City of Sacramento, it has been attempted to make use only of well established principles and processes, and to produce and employ structures, apparatus and machinery of the most thorough-going excellence and reliability. The nominal capacity of the plant, in its first stage of development, would be 35,000,000 gallons per day. Certain elements of the works would, however, have a considerably greater initial capacity.

Every possible provision has been made for future extensions of the plant, and the layout and composition are such that as each successive addition is built the plant will always appear complete and well arranged, and not "patchy."

The type of structure which has been adopted is one which will lend itself readily to effective architectural treatment. All buildings will be of reinforced concrete throughout, thoroughly fire and earthquake-proof. It is proposed that the exterior wall surfaces be given a white or warm yellow tone, and that the roofs be covered with red tile, the general composition and style being what might be termed "Spanish."

The filtration site should be laid out in beautiful gardens and lawns, and should afford a most interesting and acceptable recreation park.

The main elements in the system of filtration and pumping works would be as follows:

(1) Protection and preparation of site, including the construction of levees, general grading, building up of roads and paths, the planting of trees and shrubs, the making of lawns, gardens, etc.
(2) Intake works, including the intake pier pipe line, suction well, etc.
(3) Pumping station, boiler house and chimney, including engine foundations, store room, machinery and tool rooms, chief engineer's office, attendants' dressing room, etc.
(4) Pumping station equipment, including high and low service pumping units, drainage and flushing pumps, electric power and lighting sets, boilers, super-heaters, condensers and all accessories, with fuel and oil storage and measuring tanks, etc.
(5) Force main from proposed new pumping station to a connection with the present distribution system at Second and I Streets, including a Venturi meter, check and gate valves, etc.
(6) System of coagulating and sedimentation basins, including a preliminary grit basin, a main coagulating and subsiding basin, and two secondary coagulating basins, with necessary pipe arrangements, gate houses, flushing and cleaning devices, railings, etc.

(7) Two batteries of rapid sand filters, with filter house and head house and tower, including superintendent's office, attendants' rooms, coagulant and general store rooms, chemical and bacteriological laboratories, coagulant mixing and application devices, sterilizing solution and application devices, wash water storage tank and all regulating, indicating and sampling apparatus, etc.

(8) Filtered water reservoir, in two independent units, with covers, ventilators, circulation baffles, etc.

General Operation of the Plant.

The general operation of the plant may be very roughly described in the following terms:

The raw water of the river will be taken into an intake chamber of pier through coarse screens and large controlling sluice gates arranged at various elevations so that at all times water of the most satisfactory available quality can be taken from the river. The intake pier would be located in the stream opposite the plant and about 115 feet out from the present well-defined bank line.

From the intake pier the water would pass through an underground conduit to a suction well located near the pumping station. From this sump or well it would be lifted by centrifugal pumping units, in duplicate, and delivered into the system of sedimentation basins.

In the normal operation the water would first pass into a grit basin in which the heavier suspended matters would be deposited. Thence it would pass into a larger sedimentation basin where, aided by artificial coagulation, almost all of the finer clay and other suspended matters would be removed. From this basin the water would pass into smaller secondary coagulating basins where such quantity of coagulant would be added as would produce at all times a suitable amount of flocculent material to insure efficient operation of the filters. In these basins the storage period would be adjusted to permit thorough coagulation to occur and yet not allow subsidence to any important degree.

From the series of sedimentation basins the water would flow to the filters which would consist of beds of sand especially prepared in size and depth and controlled in rate of operation to give thoroughly satisfactory results. After having passed through the filters the water would be relieved of every trace of suspended matter, and would be rendered uniformly clear and brilliant. The bacterial content would be very low; indeed the water would be even sterile at times.

In order, however, that the bacterial efficiency may be absolutely controlled, it is proposed to add to the water either just before it passes to the filters or immediately subsequent to filtration, a minute quantity of calcium hypochlorite, which will effectively oxidize and kill all bacteria present.

The water from the filters would pass into a filtered water storage reservoir constructed in two equal independent parts. These basins would be entirely covered and would be efficiently protected from contamination of every sort. High life, high duty, triple expansion pumping engines would take the water from the filtered water basins and deliver it into the distribution system and to the consumers under such pressure as may be desired; in any case, under a considerably higher pressure than that which is now maintained throughout the City.

The plant would be complete with all necessary auxilliary devices for controlling all operations and rendering the process of purification efficient and uniform.

Estimated Cost of Construction.

The estimated cost of construction of the works roughly outlined above is $828,000, distributed approximately, by items, as follows:

Items.	Estimated Construction Cost.
(1) Purchase of land, protection and improvement of site, construction of levees, roads, gardens, lawns, etc.	$62,000
(2) Intake works, including pier, conduit, suction well, etc.	59,000
(3) Pumping station, boiler house, chimney, etc.	76,000
(4) Pumping station equipment, including pumps, engines, boilers, auxilliary apparatus, etc.	209,000
(5) Force main to distributing system, including meter, check and gate valves, etc.	54,000
(6) System of coagulation and sedimentation basins, with gate houses, pipes and appurtenances	98,000
(7) Filters, filter house, head house and tower, with with all appurtenances	90,000
(8) Filtered water basins, with covers, baffles, pipes, etc.	72,000
Total	$720,000
Add 15% for engineering contingencies, etc.	108,000
Total	$828,000

Estimated Annual Costs.

The estimated total annual cost of operation of the proposed plant, with an average daily output of 21,000,000 gallons, including all interest and sinking fund charges and the cost of pumping into the distribution system, is shown herewith, by principal items, as follows:

	Items.	Estimated Annual Cost 21 mill. gal. per day.
(1)	Interest on cost of works, at 4½%	$37,300
(2)	Sinking fund* charges to mature bonds	7,800
(3)	Maintenance	10,000
(4)	Pumping station labor	14,000
(5)	Pumping station fuel, supplies, etc.	30,000
(6)	Filtration plant and outside labor	12,000
(7)	Filtration plant supplies	26,000
	Total	$137,100

Estimated total cost per million gallons filtered	$82,000.00
Estimated operating cost properly chargeable to filtration	48,000.00
Estimated operating cost per million gallons filtered	6.26
Estimated total annual cost, including sinking fund and maintenance charges properly chargeable to filtration	91,000.00
Estimated total cost per million gallons filtered	11.90

Estimated Total Cost of Purified Sacramento River Water to Sacramento.

If to the cost of filtration and pumping, as above outlined, the cost of operating the distribution system is added, the total net cost of purified water to the City of Sacramento per unit of volume can be obtained. In estimating upon the cost of water in municipalities, it is customary to present figures in terms of cents per thousand gallons. The average annual costs chargeable to the distribution system for the years 1906-'08, inclusive, were approximately $30,000. Assuming that these costs will in the future vary directly with the volume of water consumed, it may be estimated that the annual costs when an average of 12,000,000 gallons daily are consumed will be $37,000, and when an average of 21,000,000 gallons are daily consumed the annual costs will be $64,000. The costs of operating the distribution system in recent years have been estimated from the annual reports of the City Auditor. During the past several years, with the water rates which have obtained, the city has made an average profit of about $19.60 per million gallons on sales of water. If it is desired that the same rate of profit shall obtain in the future from the sale of filtered water as now obtains from the sale of unpurified water, a charge of approximately $0.0196 per thousand gallons should be added to the annual cost obtained as outlined above. We may then summarize the cost per thousand gallons as follows:

Item.	Estimated Cost per 1000 Gallons with Average Daily Use of 12,000,000 gals.	21,000,000 gals.
(1) Purification costs	1.48c	1.09c
(2) Pumping costs	0.79c	0.64c
(3) Distribution costs	0.84c	0.84c
(4) Profits	1.96c	1.96c
Total	5.07c	4.53c
Total without profits	3.11c	2.57c

It is apparent that the necessary net cost of water to consumers in Sacramento would be the total costs as above given, less the profits from the sale of water. The estimates for an average daily consumption of 12,000,000 gallons and of 21,000,000 gallons are respectively only a trifle over 3 cents and 2½ cents. With the addition of profits such as were made from the sale of water during the three years 1906-'08, these figures would be, respectively, only a trifle over 5 cents and 4½ cents.

In the above estimates, a considerable annual sum has been included to cover extensions to the distribution system. The figures do not include interest or sinking fund or depreciation charges on the distribution system nor interest on that part of the present pumping equipment which will be utilized in the new works.

Comparison of Cost of Water in Sacramento With the Cost in Other California Communities.

It may be of interest in this connection to compare the cost of water in Sacramento, both unpurified and purified, with the cost of water in certain other typical communities in California in which both private and public ownership are represented. The figures of cost in the table immediately following are expressed in cents per thousand gallons of water. These figures have been obtained by dividing the total receipts from the sale of water by the total volume of water, expressed as thousands of gallons, delivered into the distribution systems.

Cost of Water per 1000 Gallons
In Certain Cities of California,

As obtained by dividing the total receipts for Water by the total volume of water delivered into the distribution systems.

Place.	Cost per 1000 Gals.	Year.	Ownership.
Alameda	25.0c	Recent	Private
Berkeley	33.0c	Recent	Private
Los Angeles	0.5c	1904	Public
Oakland	18.0c	Recent	Private
Sacramento, unpurified*	3.3c	av. 1906-'08	Public
Sacramento, purified**	5.1c	1915	Public
Sacramento, purified***	4.5c	1945	Public
San Francisco	16.9c	av. 1902-'07	Private
Santa Clara	6.6c	av. 1901-'06	Public

The figures for Sacramento are subject to the conditions stated in the last paragraph of the discussion, entitled "Estimated Total Cost of Purified Sacramento River Water to Sacramento." In some respects the assumed figures of cost of water in Sacramento do not afford a strictly accurate basis of comparison with the cost of water in other communities, especially those served by private water works, because they do not include interest and sinking fund charges or the equivalent depreciation charges on that portion of the present pumping installation which will be utilized in connection with the new works, nor do they include these charges on the distribution system. In the case of private works sinking funds are rarely or never established, and interest is usually allowed on the present value of the entire investment from the inception of the works to any date in question. The writer has at hand no figures to show the present value of the distribution system in Sacramento with suitable allowance for depreciation. If this were known, interest and depreciation or sinking fund charges could be added to the figures given above to give a basis of comparison with cost

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*Including profits. **With 12 million gallons daily. ***With 21 million gallons daily.

of water from private works. However, this increment would be comparatively small. The figures as given do represent closely the actual annual costs of the entire system of works to the community, under the conditions which obtain today, since there are no outstanding bonds covering any portion of the distribution or pumping systems.

It will be seen from the above table that the cost of water in Sacramento, both purified and unpurified, under the conditions which obtain, or which are assumed to obtain in the future, are very much less than the cost of water to consumers in other municipalities, especially in towns supplied from private works. The cities included in the table are those for which the data could be ascertained, in other words, those for which reasonably close figures of income and consumption were available.

It may further be of interest to present figures showing established basic maximum meter rates per thousand gallons in some of the principal cities of California. This table includes twenty-four cities and towns, of which number ten cities and towns own and operate their own works, thirteen cities and towns are supplied from private works and one city, namely, San Diego, acts as a retailer of water purchased at wholesale and delivered to the city distributing reservoirs.

Established Basic Maximum Meter Rates
Per 1000 Gallons in Certain Cities of California.

Place.	Rates Per 1000 Gals.	Ownership.
Alameda	$0.30	Private
Bakersfield	.10	Private
Berkeley	.35	Private
Los Angeles	.097	Public
Modesto	.20	Public
Oakland	.338	Private
Palo Alto	.135	Public
Pasadena (a)	.20	Private
" (b)	.08	Private
Petaluma	.40	Private
Red Bluff	.35	Private
Redlands	.10	Private
Riverside	.22	Private
San Diego	.10	Private Supply, Public Distribution

San Francisco	.333	Private
San Jose	.33	Private
San Luis Obispo	.25	Public
Santa Ana	.13	Public
Santa Barbara	.25	Public
Santa Clara	.20	Public
Santa Cruz	.15	Public
Santa Rosa	.25	Public
Stockton	.25	Private
Vallejo	.20	Public
Watsonville	.25	Private

Results Which May Be Confidently Expected From the Operation of the Proposed Purification Works.

If the proposed plant is constructed and operated in accordance with the scheme outlined by the writer, the people of Sacramento may anticipate with confidence, among others, these very important and significant results: (1) The production of a uniformly clear and brilliant water supply; (2) the production of a supply continuously and entirely free from disease germs; (3) an increase in water pressure throughout the city: (4) a decrease in sickness and death caused by typhoid fever and other diseases which are either directly or indirectly associated with the water supply.

In previous discussions the writer has shown that the annual money value of improvement can be safely and rationally figured in 1915 and 1950, respectively, as 2 and 4 times the entire annual costs of purification. Such figures are based, as explained in the discussions in question, upon the tangible value of lives saved, due to the better sanitary quality of the water, and upon the somewhat intangible but nevertheless real value of improved quality as viewed from the aesthetic standpoint. But, as stated by the writer heretofore, "the value of the improvement cannot be judged by any one standard, nor from any single point of view. Certain phases of this improvement may properly be expressed in the terms of dollars and cents; others in such aesthetic terms as satisfaction and pleasure from use; still others in terms which are perhaps ethical and altruistic and have to do with the reduction of human suffering, an increase in human happiness and safety, the promulgation of human peace and comfort." "The health of a community is its greatest asset without which wealth cannot be produced, and comfort, safety and happiness would be unknown."

Summary and Conclusion.

Holding in review the various matters discussed in the foregoing report, and in consideration of the several more important features of this entire project of supplying the City of Sacramento with an abundant and pure supply of water, your sub-committee begs to submit the following summary and conclusion:

(1) The City of Sacramento is fortunate to an unrealized and almost unrealized degree in having at its very threshhold a vast river whose flow is unceasing and whose waters are so abundant that no storage reservoirs will ever be required. no matter how large nor how extravagant in the use of water the City of Sacramento may become. The minimum flow of this mighty river is fully 4000 million gallons in twenty-four hours, and the average flow fully ten times this quantity.

(2) The works required for the diversion of any desired amount of water from Sacramento River are relatively very simple and inexpensive, and they may be made wholly reliable, no matter by what standpoint they are judged.

(3) Sacramento may confidently anticipate a brilliant future, and will undoubtedly enter upon a larger development than has been thought possible. With the growth in population, prosperity, industries and commercial activities will undoubtedly come larger and larger legitimate demands for water. Sacramento River, at the very doors of the City, will be sufficient to supply these needs for all time to come. Its minimum rate of flow is now entirely adequate to meet the requirements of from five to ten times the present total population of the entire State of California.

(4) The water of the Sacramento River is wonderfully soft, and in its natural state was entirely free from color and turbidity. But it is now polluted by sewage and rendered muddy at times by washings from agricultural lands and by debris resulting from past mining operations.

(5) By proper purification methods we are confident that this water may be rendered as pure, colorless and wholesome, and even more brilliant than it must have been in the ancient days before so-called civilization cast its contaminative influences upon the stream.

(6) The purification of water has become practically nothing less than a science; it is no longer an experiment. The experience of several million people in the United States, or more than one in every five persons living in places publicly supplied with water, demonstrates that the results of water purification can be controlled and made to be all that can be desired.

(7) A comparison of Sacramento water with that of other streams in the United States from which purified supplies are derived, shows that the problem of Sacramento is more simple and more readily handled than that of the major number of communities satisfactorily supplied from these other sources.

(8) Not only may the diverting pumping works be made absolutely reliable, but such purification works as may be required for this city may also be made reliable to the same degree.

(9) The required purification plant may be extended indefinitely in such a way that the structure may at any time appear complete and systematic.

(10) The construction of purification works will unquestionably reduce to a marked extent typhoid fever and other intestinal diseases now occurring in the city. A conservative estimate of the financial value of the lives which could be saved in 1915 through the intervention of a filter plant would be $140,000, or perhaps from one-third to one-fourth of the total estimated cost of the necessary purification works, exclusive of pumping machinery, etc., which would be required whether the purification plant is built or not. In 1950 the annual financial benefit of purification, conservatively estimated, should be nearly $500,000.

(11) The use of a purified water supply derived from the Sacramento River in the immediate vicinity of the City would seem to be the most logical solution of our water problem that can be devised.

(12) Homeseekers and tourists are becoming sufficiently educated so that they now seek places for residence and pleasure wherein are provided good and pure water supplies, and they shun those places where impure waters are purveyed.

(13) Eastern cities wherein modern filter plants have been built are advertising these plants as important features conducive to healthful and pleasant living conditions.

(14) Filter plants have been constructed or are under way for many of the larger cities in the United States, for instance: Philadelphia, Baltimore, Pittsburgh, Washington, Cincinnati, Louisville, New Orleans, Columbus, Minneapolis, Albany, Grand Rapids, Washington, Wilmington, Harrisburg, Springfield, Indianapolis, Toledo, New Haven and fully 250 other places having at least 3000 inhabitants. It is proposed to filter every drop of water supplied to the city of New York and the City of St. Louis. Filter plans are projected for many other important places.

(15) With such filtration works as are proposed, additional quantities may be taken from the Sacramento River at any time in the future without cost for water rights. Water is becoming increasingly valuable in California. If any sort of supply be purchased the question of how extensions may ultimately be made, and the probable cost of such future extensions must be carefully considered. In view of the prospective rapid growth of this City, no source or series of sources should be considered which cannot furnish 100,000,000 gallons of water in twenty-four hours as a minimum future development. If, for instance, 30, 40 or 50 million gallons per day are represented as the ultimate diversion of any source, the questions must be asked, Where should the City go for a suitable supply after that given limit is reached? and What will be the cost of acquiring this additional source when water is much more valuable than it is today? Considering the almost incalculable advantage of having an unlimited supply of water ready for diversion, coupled with purification, without one cent of cost for the rights.

(16) With the effective laws in this State protecting the inland waters of California from gross pollution and under the physical conditions which exist in regard to irrigation and reclamation, it is not to be anticipated that the water of Sacramento River will deteriorate in the future to any marked extent, and certainly never to that point where it may not with absolute certainty and without difficulty be rendered pure and wholesome and of brilliant appearance by well established purification methods.

(17) If a purified soft water supply is introduced into the City it will become available to the various hotels, institutions and establishments which are now forced, because of the present contamination of the water supply, and because of its ill-appearance, to use independent supplies, generally obtained from underground sources. These supplies of water, while clear and generally safe, are in all cases extremely hard and undesirable on that account. Moreover, in some instances, they are undoubtedly exposed to pollution, if not actually grossly polluted.

(18) It is the opinion of this committee that the comprehensive report by Mr. Hyde in 1909, with such modifications as recent conditions may render necessary, and such other reports as may be furnished with reference to the purification of the water supply of Sacramento, should be published in full as City documents, and thus be made available to the citizens of Sacramento.

(19) In conclusion your sub-committee earnestly recommends the following action:

(a) That an option be at once secured on at least forty acres of land lying immediately north of the City as a site for future purification works.

(b) That the matter of the issue of bonds in the sum of $1,000,000, or such sum as may be required to construct a most reliable, adequate and efficient plant, be at once brought before the voters of the City.

Respectfully submitted,

J. L. GILLIS,
MRS. A. M. SEYMOUR.
ALFRED DALTON.
MRS. C. E. McLAUGHLIN,
S. W. DOWNEY.

June 6, 1913.

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